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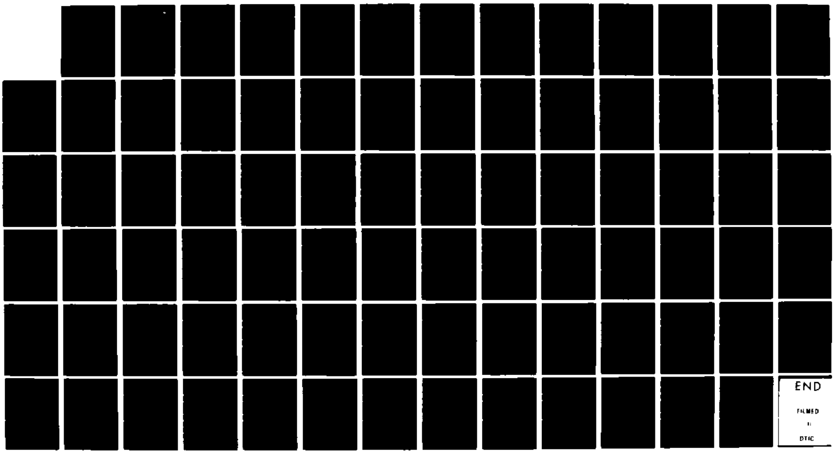

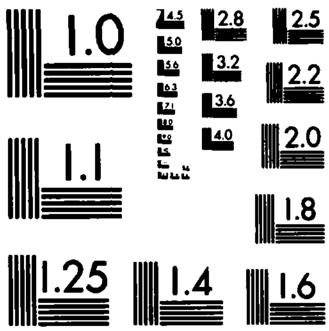

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Department of Aeronautics
Dean of the Faculty
United States Air Force Academy
Colorado 80840

CATAPULT DYNAMICS IN A HIGH ACCELERATION ENVIRONMENT

TECHNICAL NOTE
USAFA-TN-82-5

Higgins,A.M.

15 OCTOBER 1982

This Technical Note is approved for publication.

Thomas E. McCann

THOMAS E. MCCANN, Lt Colonel, USAF
Director of Research and Continuing Education

Foreword

This Technical Note is the final report covering the period 1 Oct 79 to 30 Sep 81 in response to AF Flight Dynamics Laboratory project order no. WAL 03019 which was administered by Mr. James M. Peters. Major A. M. Higgins was the Principal Investigator and was aided by staff and cadets at the Air Force Academy.

CATAPULT DYNAMICS IN A HIGH ACCELERATION ENVIRONMENT

A.M. Higgins*

Abstract

This paper presents the results of a test program in which ejection catapults were test fired both in an environment of zero acceleration (catapult horizontal) and in a high acceleration environment. These test results showed a marked effect of G loading on the catapult dynamics. The catapult pressures, for example, were significantly higher. This paper also describes an attempt made to construct a computer model which would predict the catapult's dynamics under any G loading. A discussion of the model results is included, as is the computer model program.

I. Introduction

Modern fighter aircraft are using sustained high acceleration maneuvers as a useful combat technique. As a result, the trend toward increasing the sustained "G" loading capability of these aircraft promises to continue. One method used to enhance the aircraft's maneuverability and, consequently, its G loading, is the relaxation of the aircraft's stability margin. The F-16 fighter aircraft, for example, is the first modern aircraft with a negative stability margin (the only other was the Wright Flyer). Because of this negative stability margin the F-16 must be controlled by on-board computers and, consequently, damage to or failure of these computers could result in an uncontrollable aircraft, which would require emergency escape in a high acceleration environment.

The possibility of encountering these large impressed G fields during the escape event (up to 12 Gs) has a significant

*Major, USAF, Associate Professor of Aeronautics, DFAN

impact on emergency crew escape system design. Of particular interest is the effect of this imposed acceleration field on the performance of the ejection seat's catapult. Some analytical work has been done previously to predict the performance of the ejection catapult in a high G environment (Refs. 1 and 2) but no actual tests of an ejection catapult in a high acceleration field have been found. The results of the study reported in Ref. 1 were surprising. The study concluded, for example, that much higher internal catapult pressures would be encountered, and the ejection seat timing sequence would be markedly altered by the imposed acceleration field. The study also predicted much higher acceleration of the ejection seat and therefore higher loads on the ejectee.

It therefore became clear that more study and tests were required to fully understand the effects of imposed acceleration field on escape catapults. As a result, the Air Force Flight Dynamics Laboratory (AFFDL) and Air Force Aerospace Medical Research Laboratory (AMRL) initiated a joint test program in 1978 to determine these effects. The objective of this paper is to analyze these catapult test firing results and to report on the effort made to model the ejection catapult dynamics.

II Catapult Tests

A. Approach

It would seem that the simplest test approach would be to obtain a number of new escape catapults and then fire them in a

high G environment. However, to reduce the expense of the initial test program it was decided to obtain "outdated" catapults that had been removed from operational ejection seats. Because these catapults had been exposed to temperature cycling, vibration, and aging it was necessary to complete a series of tests to establish the repeatability of the catapult's performance prior to conducting tests of catapults in a high G environment. This was done with the experimental set-up shown in Figure 1. Essentially, the catapult had one end locked to the test track while the other end was free to move against a mass (payload) resting on the test track rails. This payload sled weighed 395 pounds. As one end of the catapult was locked to the track and was therefore unmoving, these tests were referred to as <u>static</u> or zero G tests. The tests were also used to establish an expected range of data, e.g., a baseline catapult pressure-time curve, and served as an instrumentation check-out prior to the <u>high-G</u> or <u>dynamic</u> tests.

The acceleration environment for the dynamic tests was generated by the test set-up shown in Figure 2. Both the payload and carrier sled were accelerated to a predetermined velocity, and then the brakes on the carrier sled were actuated. This resulted in a decelerating force being applied through the catapult to the payload. After the accelerometer on board the carrier sled sensed the preselected G level, the catapult was ignited and propelled the payload sled. The nominal G level for all the dynamic tests was selected to be 8 Gs (Ref. 3).

Thus the test approach was first to conduct static tests to establish data repeatability and a base-line data set. Then the dynamic tests were to be conducted and compared to the static data to determine any changes in catapult performance due to imposed acceleration field.

B. Test Apparatus

Three elements were needed to conduct these tests: (1) the test track facility which includes the payload and carrier sleds, (2) the escape system catapults, and (3) the various transducers used to sense the required data. The test track facility also includes a launch system, which propelled the catapult-sled system down the track for the dynamic tests, and appropriate electronics equipment to transmit, condition, and record the test data.

The Talley 2400 series catapult was used in these tests, and the data sensed and recorded are shown in Table 1. The specifications for each of these transducers and their installation are discussed more fully in Ref. 4.

C. Test Results

1. General

The data recorded during these tests were previously listed in Table 1. The primary parameter of interest throughout this analysis is the catapult pressure, since this is an indication of the energy released by the catapult and serves as

the driving force that produces the accelerations and displacements that follow. A sample data set for test 159 is included as Appendix A.

2. Static Tests

There were 24 catapult test firings during this test program. Twelve of these tests were static tests; Table 2 lists the identifying test numbers for both the static and dynamic tests.

The pressure curves for the static tests can be grouped into three sets. The first set (called Set No. 1) is composed of five tests (155, 157, 158, 159, 160); the results of these tests are used during the remaining analysis as "standard" catapult results. The rise in pressure is smooth without sharp drops or increases. Each pressure curve in this set is essentially identical with the others. Figure 3 shows this pressure relationship for two of the tests, nos. 159 and 160. The spike in pressure near the end of the catapult stroke (time of stroke is approximately 160 milliseconds) will be discussed shortly.

Set No. 2 is composed of three tests (161, 162, 165); each of the catapult pressure-time curves of this set is similar to the others but lower in amplitude and impulse than those of Set No. 1. The pressure spike is again evident in each of these tests. Figure 3 includes the pressure-time curve for test no. 161 to show the typical lower impulse of Set No. 2.

Set No. 3 is also composed of three tests (154, 156, 163) and these are similar in impulse to Set No. 2. The major difference between Set Nos. 2 and 3 is the delay in pressure onset. For Set No. 2 the sustained pressure rise starts at 20 milliseconds after the ignition signal. For Set No. 3 the sustained pressure rise starts at 40 milliseconds after the ignition signal. This pressure rise for Set No. 3 is rapid at first, and then assumes essentially the same track as the pressure curve in Set No. 2. Another difference is that two of the tests in Set No. 3 (154 and 156) do not exhibit the pressure spike at catapult separation (strip-off).

Test no. 164 is different from all of the other tests in that the pressure curve is very positive at the beginning and then goes to zero and then begins its steady rise.

If the accelerations of the first two sets of data are compared, it is obvious that, as expected, the lower pressures of Set No. 2 give rise to lower accelerations than in Set No. 1. Figure 4 is a plot of the catapult acceleration of test no. 165 (Set No. 2) versus test no. 158 (Set No. 1) and clearly shows this reduced acceleration for Set No. 2. It is also interesting to examine the acceleration curve for test no. 164 to see if the large pulse in pressure is reflected in the payload sled acceleration-time curve. Figure 5 shows that it is not. Thus it is hard to explain the pressure-time curve for test no. 164. As a result, the catapult pressure transducer was changed for the next test, test no. 165. In fact, three pressure transducers

were used during the tests. The first pressure transducer was used for tests 154 through 164, the second for tests 165 through 186, and the third for tests 196 through 198. It should also be mentioned that the transducer connection to the catapult chamber was changed after test no. 156. This was done to reduce the apparent lag in the catapult pressure response as compared with the force and acceleration response. The original configuration consisted of approximately seventeen inches of quarter-inch diameter tubing with two 90 degree bends and a 90 degree connector. This was changed to one inch of tubing with the 90 degree connector, thereby eliminating the lag. One other noteworthy change in pressure transducer instrumentation was made. The transducer pressure line was packed with silicon grease to protect the transducer from hot gases in test nos. 154 through 158. The use of this grease was discontinued until test no. 196 and then used again with the third transducer during test nos. 196 through 198.

In many of the static tests results a pressure spike appears at the time of catapult strip-off. These spikes are seen in each of the pressure-time plots in Figure 3. Upon closer examination it is clear that the beginning of the spike occurs just at the time of strip-off. It appears that this pressure increase occurs for the following reason. Prior to strip-off the catapult propellant is burning and therefore producing high pressure gas within the catapult tube, forcing the internal catapult tube (piston) out of the external tube (cylinder) as shown in Figure

6. At strip-off the internal tube pulls out of the "end-cap" leaving a hole in the end-cap. The end-cap motion relative to the external tube is stopped by mechanical interference. Hot gas then flows through the end-cap hole and into the rocket nozzle and ignites the rocket. The important point here, however, is that the rapid increase in volume that was occurring prior to strip-off ceases with the stopping of the end-cap. The catapult propellant is still burning, however, and the pressure in the catapult momentarily increases rapidly until the propellant is consumed and then drops rapidly with the gas flow out of the internal tube through the end-cap hole. If this analysis is correct the peak of the spike could be used as a measure of propellant burn-out. It is interesting to note that during the dynamic tests where more catapult propellant is needed due to the greater burn time, pressure spikes are observed cnly in test nos. 185 and 186. The behavior of the pressure curve in test no. 184 must be discounted as there was a break in the signal cable.

After this review of the static test data from the catapult firings and the pressure transducer modifications, data Set No. 1 was selected as the representative static test data for comparison with the dynamic test results. These five tests seem to be reproducible and representative of the Talley 2400 series catapult.

3. High-G Tests

Twelve high-G tests were conducted; these test numbers are listed in Table 2. The G level applied to the catapult in these tests was a nominal eight Gs but varied during each test and from test to test. This was necessitated by the difficult job of precisely braking the carrier sled. Figure 7 is a plot of the carrier sled acceleration in Gs for test no. 183 and shows that the deceleration varies between seven and nine Gs. A sample data set for the dynamic tests (again test no. 183) is listed in Appendix B. Because of the varying load on the catapult, little effort was made to correlate the high-G test results. A simple check of the output of the force transducers mounted at each end of the catapult was made. Figure 8 shows these values to be in very close agreement, as they should be.

4. Comparison of Static and High-G Tests

The first relationship investigated for this comparison was the effect of G loading on catapult pressure. Figure 9 compares the pressure-time curves of test no. 159 (static) with those of test no. 183 (high-G) where zero time is the onset of the catapult pressure rise. Notice that the maximum catapult pressure for the static test is 1499 psi (neglecting the pressure spike after catapult strip-off) versus 2202 psi for the high-G test. If we examine the catapult extension time from ignition to strip-off we find that for test no. 159 it takes 150 milliseconds to reach strip-off, while for test no. 183 it takes 195 milliseconds. However, the actual stroke time of the

catapult was 126 milliseconds for the dynamics test, no. 183, versus 134 milliseconds for the static test, no. 159. This is a typical comparison between the static and high-G tests and confirms the results of the earlier study (Ref. 1).

5. Conclusions

Although there was some significant variation in the static tests, a group of tests was selected as representative of the Talley 2400 series catapult and was used as "standard" data for computer modeling purposes.

Significantly higher catapult pressures were obtained during the high-G catapult tests, as expected (Ref. 1). Also, the time required for the catapult to reach separation was longer for the high-G tests than for the static tests.

III. Computer Model

A. Background

The computer model of an ejection catapult used in this study is a revised version of the model used in the 1975 catapult study (Ref. 1). Certain changes were made to the early program to improve or extend its capabilities and these changes will be discussed in the theory section of this report. The purpose of this program, however, remains the same: to provide a means of predicting escape catapult phenomena under any G loading at any initial propellant temperature.

B. Model Theory

The catapult computer model is composed of various governing equations. These are summarized below:

1. Energy Balance (First Law of Thermodynamics)

$$W_{\substack{\text{out of}\\\text{gas}}} = mC_v \Delta T - Q_{\substack{\text{out of}\\\text{gas}}} \tag{1}$$

2. Perfect Gas Relationship (Equation of State)

$$PV = mRT \tag{2}$$

3. Force Balance

$$EJM * ACCEL = (CADF - FRF - FPF) \tag{3}$$

4. Propellant Burn Rate Equation

$$r = {}^{dL}/dt = kP^n \text{ (inches/time)} \tag{4}$$

5. Propellant Form Function

$$m = f(L) \tag{5}$$

Eqn. (1) states that the energy removed from the hot gas ($mC_v \Delta T$) goes to heat transfer (Q) or to work (piston motion or equivalently, payload motion). The perfect gas relationship, Eqn. (2), is standard and is used with an appropriate value of the gas constant R selected for the propellant gas. The force balance, Eqn. (3), merely states that the force of the catapult, CADF, minus the rail friction, FRF, and O-ring friction, FPF, equals the resultant force on the payload. In this expression, EJM is the ejected mass and thus ACCEL is the resultant payload

acceleration. The propellant burn rate equation, Eqn. (4), relates the catapult internal pressure to the length of propellant burned. The variables k and n in Eqn. (4) are constants taken from Talley's propellant data sheet. Finally, the propellant form function, Eqn. (5), relates the length of propellant burned to the mass of propellant burned. This mass is the same as the mass, m, in Eqn. (1). These equations are combined in the program in one of two ways. The first technique requires the form functions to be known, and then the equations are structured to calculate the catapult temperature, pressure, acceleration, velocity, and displacement. A flow diagram for this technique is shown in Figure 10. The second technique uses known pressure data to calculate the form function for the catapult. A flow diagram for this technique is shown in Figure 11. Since the form function relates propellant mass burned (W) to propellant length consumed (WB), then if the length of propellant burned is known, i.e., the pressure-time curve is known, the amount of propellant can be determined.

The computer model is capable of using both techniques. In the present analysis the latter technique is used first in order to calculate the propellant form function using the known test data. This technique is used because the form function for the propellant at high pressures (high-G tests) is unknown.

C. Modeling Approach

The approach used in the modeling effort was to use the actual test data to create a "universal" form function for the Talley 2400 series catapult. With this form function known, any G loading could be prescribed along with other descriptive parameters such as seat weight, and the resulting output parameters, such as catapult pressures and seat/man accelerations, could be calculated with the computer model. A single form function does exist for tests in a one G environment; the present approach assumes that a single form function exists for all G loadings.

This approach requires, of course, a computer program that correctly generates a form function from the pressure data and that this form function can then be used to regenerate the pressure, acceleration, velocity, and displacement information of the original test. In short, the computer model must be mathematically accurate.

D. Data Manipulation

Rapid Analysis of computer program output requires the ability to quickly plot this output data either alone or with the experimental test results. This was accomplished through the following tests:

1. Statements were added to the computer program logic to cause the following output parameters to be stored in a separate data file: (1) pressure, (2) displacement, (3) acceleration, (4)

propellant burned (W), and (5) web burned (WB). Thus the pressure file would contain digitized values of pressure at two millisecond intervals throughout the catapult stroke. These files are identified by test number and can be easily called up for viewing or plotting at any time. For example, the computer-generated pressure data for test no. 159 are stored at P159.

2. A program was written to modify the experimental data taken from computer cards to make it compatible with the computer model output data. This program, DATA/MOD, changes the format of the data, eliminates the appropriate number of initial data points, selects the appropriate time step between data points, and stores the data. For example, it eliminates every other data point if data at two millisecond intervals are required. A copy of this program is included in Appendix C.

3. Various plotting routines have been created to plot recurring data formats. For example, the computer program GRAPH plots the computer model-generated payload sled acceleration versus the measured payload sled acceleration and stores the plotfile for future reference. The name of this plotfile for test no. 159 is PLOTFILE/GVSG/159 and to plot this data comparison at any time in the future one simply has to type the command PLOT and then PLOTFILE/GVSG/159. A copy of GRAPH is included in Appendix D.

E. Programming Changes

Numerous program changes were made during the model analysis period. A copy of the final version of the program is included in Appendix E. The input data required for the catapult program, NEWSET, are also listed there. Only the more important changes will be discussed here and these can be grouped under the following three headings: (1) removal of the igniter charge, CO, (2) modification of the calculation of rail friction, and (3) inclusion of imposed G field. The modification to permit output information to be sent to data files was a fourth major change, but this has been previously discussed.

1. Removal of Igniter Charge

Early in the evaluation of the technique used to create a form function from the experimental data, an attempt was made to compare the experimental pressure-time data used to calculate the form function to the pressure-time data resulting from the form function. These curves did not match. After some analysis it became clear that the amount of propellant needed to generate the pressure-time test data was being properly calculated. In the second phase of calculations, in which the form function was used to calculate the pressure-time curve, an extra amount of propellant, the igniter charge, was being added to the mass of propellant indicated by the form function. This extra propellant resulted in higher catapult pressures than those recorded during the actual test. When the igniter charge, CO,

was removed from the program logic, the pressures matched nicely, as shown in Figure 12 for test no. 183.

2. Rail Friction Modification

Later during this model analysis it was noticed that, although the experimental and calculated pressure-time curves matched for the static tests, the payload sled displacement (catapult displacement) did not. The displacement calculated by the computer model was significantly less. Examination of the computer model force balance [similar to Eqn. (3)] revealed that if the driving force, CADF, was calculated correctly (remember that the catapult pressure curve had been proven correct earlier and that the catapult end area was measured) and the ejected payload mass, EJM, was measured correctly, then the friction terms must be incorrect. Rail friction was previously calculated as 0.356 using the results of an actual track test (Ref. 5). Using the data from test no. 159 a value of O-ring friction was calculated as 0.008. These two values were inserted for K1 (changed from 0.2 to 0.008) and K2 (changed from 0.01 to 0.356) in the program logic. Also, the original logic, which attempted to incorporate the effect of sled movement (sled "rocking" on the track during translation along the track) on the rail friction term, was removed. With these new values and formulation, the new value of catapult displacement was determined by twice integrating the revised catapult acceleration predicted by the model. Figure 13 is a plot of the acceleration-time curves for

test no. 159 and compares the actual (test) catapult acceleration to the computer model's prediction. The fit is very good. The displacements were next compared and, as expected, the correlation was excellent.

A note of caution must be included here concerning the friction coefficients. These values change with test and track conditions, and in particular the O-ring friction value can be expected to change for the high-G tests due to pressure increases in the catapult. The changes in friction may be the cause of the variation in acceleration seen in Figure 14 (GVSG 159-161), since the O-ring friction coefficient was determined from test no. 159 data. Remember that the pressure curves correlate well for these two tests.

4. Inclusion of Imposed G Field Data

The G loading on the catapult is not constant, as previously discussed (Figure 7), and therefore the actual values of G loading, rather than a nominal or average value, should be input to the force balance in Eqn (3). Of course, Eqn. (3) must be modified to reflect this G-loading consideration. Representative G-loading data have been added to the program for various tests. These data can be called into the program as ZLF or program line 20820.

IV. Form Function Analysis

A. Calculations

The remaining task was to determine if a universal form function for the Talley 2400 series catapult exists. The approach was to use the actual data from the catapult tests to generate propellant form function curves (i.e., mass of propellant burned, W, plotted versus length of propellant burned, WB) and to compare them.

First, certain static tests were used to generate separate form function curves. A typical comparison of two separate form function curves for test nos. 159 and 160 is shown in Figure 15. The agreement is excellent, but it must be remembered that the results from these two tests were very similar, and good agreement would be expected. Indeed, the propellant burn rate depends only on the pressure, as shown by Eqn. (4), so that if the pressure-time curves for separate tests are the same, then burn rate and its integral, propellant length burned, must be the same.

Before the form function could be created for the High-G tests, an appropriate value of catapult acceleration had to be generated within or supplied to the catapult model. This acceleration would then be twice integrated to determine catapult stroke which is required to calculate the work term in the energy balance, Eqn. (1). It is also used to determine the latest value of catapult internal volume used in Eqn. (2). The standard technique for calculating this acceleration would be to formulate a new force balance for the high-G tests. This formulation would necessarily contain the friction forces discussed earlier and

would require a careful review prior to use. As this review could be time-consuming and require additional information on the friction factors, particularly O-ring friction, an alternate technique was used. Since the difference in payload sled acceleration and carrier sled acceleration is their relative acceleration or catapult stroking acceleration, then this difference could be used as input to the computer model to complete the high-G form function calculations. This was done by storing this relative acceleration (difference) in the test no. 183 G data file (shown in the computer program in Appendix E). This value of acceleration was then read into the computer program (line 21610). To check this technique, a plot of the resulting displacement of the catapult was compared to the actual catapult stroke data. This comparison is shown by Figure 16. The agreement is excellent.

With this program adjustment the form function could be calculated for the high-G tests. If we compare the resulting form function from a high-G test (test no. 183) to the one from test no. 159 (a static test), the Figure 17 results. The pressure-time curves for these two tests were previously shown in Figure 3. Unfortunately, the two form functions in Figure 17 are not the same. If we look more closely at each form function by plotting the propellant burned, W, versus time, as well as burn length, WB, for both tests, then Figures 18 and 19 result. Notice that Figure 19 shows that the web burned is about the same for test no. 159 as for test no. 183. This is surprising as the

pressure curves are significantly different after the 80 millisecond point. This suggests that the burn rate equation may not be as sensitive to pressure as it should be. Of greater concern, however, is the result shown in Figure 18. This result shows that more energy is expended (more propellant is burned) in the static test than in the high-G test. This, of course, is incorrect. Not only does the catapult do more work during the high-G tests, since the catapult pressure is higher, but also the burn time is increased, which allows more time for thermal energy transfer.

B. Conclusions

It is not clear why the discrepancies mentioned above occur. At this point, it appears that the program logic still needs further refinement and that perhaps a single form function exists for the Talley 2400 series catapult regardless of the G loading. Further analysis of the thermal energy loss term, the burn rate coefficient and exponent, and calculated fuel consumption magnitude should be done. Also, the magnitude of the work term must be determined and compared for both the static and high-G tests. For example, does the program output show a larger value of work for the static or high-G tests? Although the present investigation ended before this analysis could be completed, this analysis is the next necessary step in the catapult model building process.

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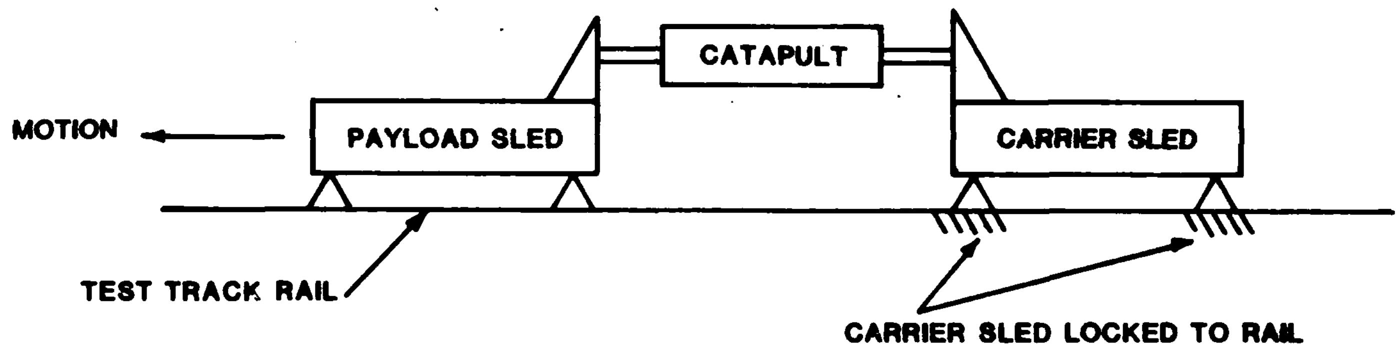

Figure 1. Schematic Diagram of Experimental Set-Up for Static Test of Ejection Catapult

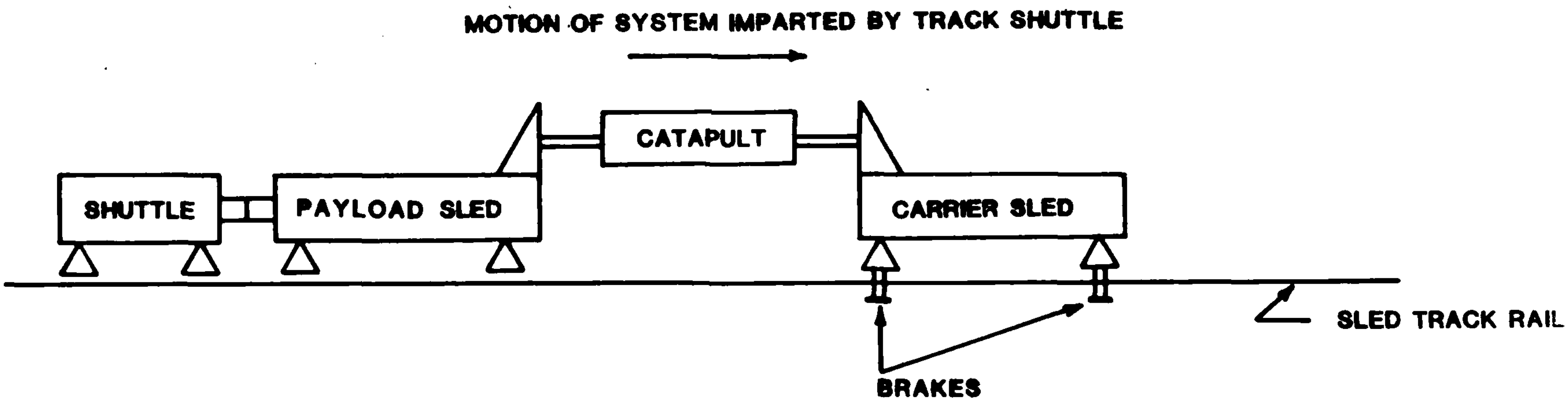

Figure 2. Schematic Diagram of Experimental Set-Up for High-G Test of Ejection Catapult

Table 1
PARAMETERS MEASURED DURING EJECTION CATAPULT TESTS*

PARAMETER	TEST SERIES
Payload sled x-axis acceleration	Static and High-G
Force applied to payload sled	"
Force applied to carrier sled	"
Internal gas pressure of catapult	"
Displacement of payload sled	"
Velocity of carrier sled	"
Carrier sled x-axis acceleration	High-G Tests Only
Carrier sled y-axis acceleration	"
Carrier sled z-axis acceleration	"

*Ref. 4

Table 2
IDENTIFYING TEST NUMBERS
OF CATAPULT FIRINGS

STATIC TESTS (12 tests)	HIGH-G TESTS (12 tests)
154	171
155	178
156	179
157	180
158	181
159	183
160	184
161	185
162	186
163	196
164	197
165	198

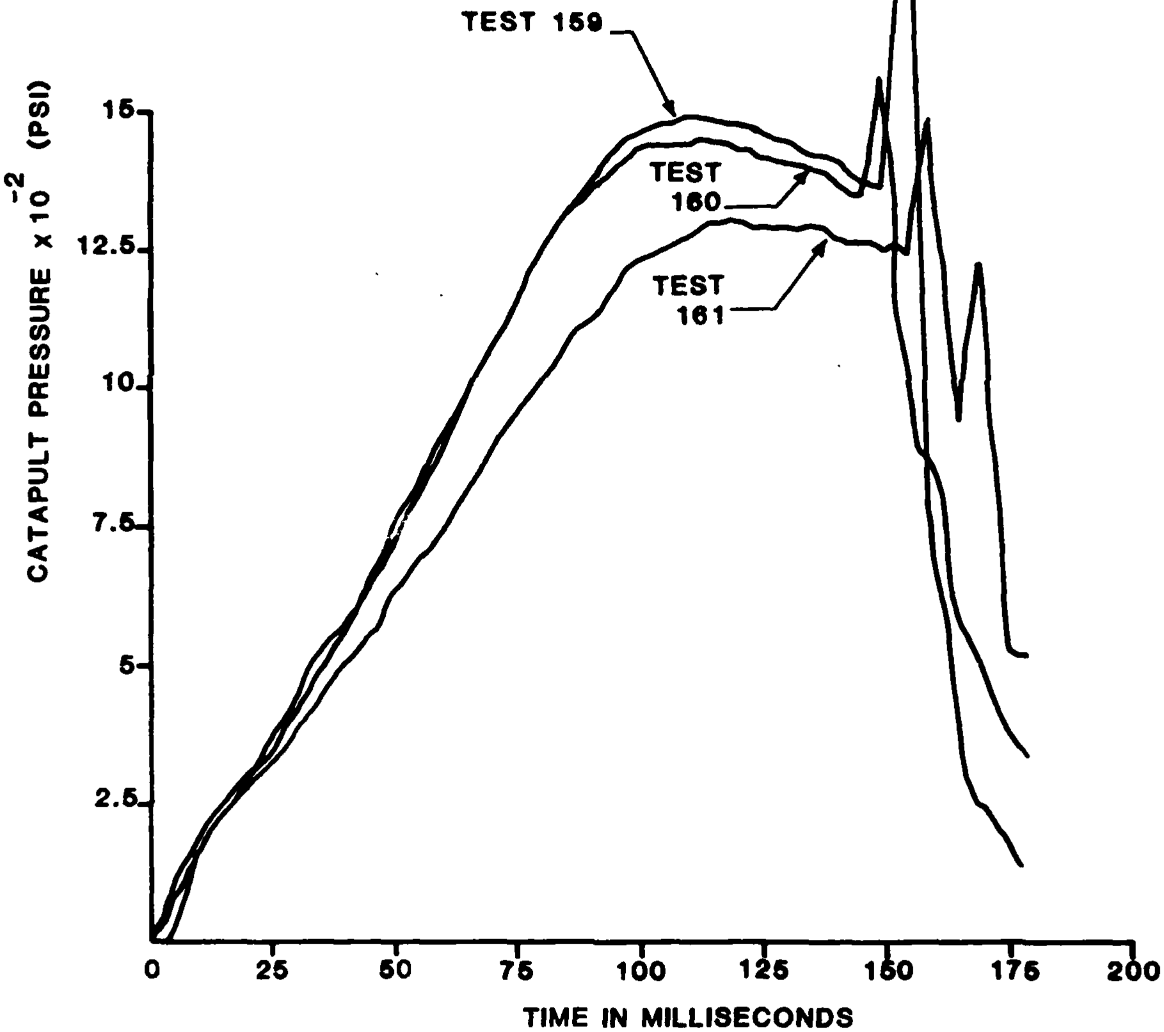

Figure 3. Catapult Pressure Test Data for Test Nos. 159, 160, and 161

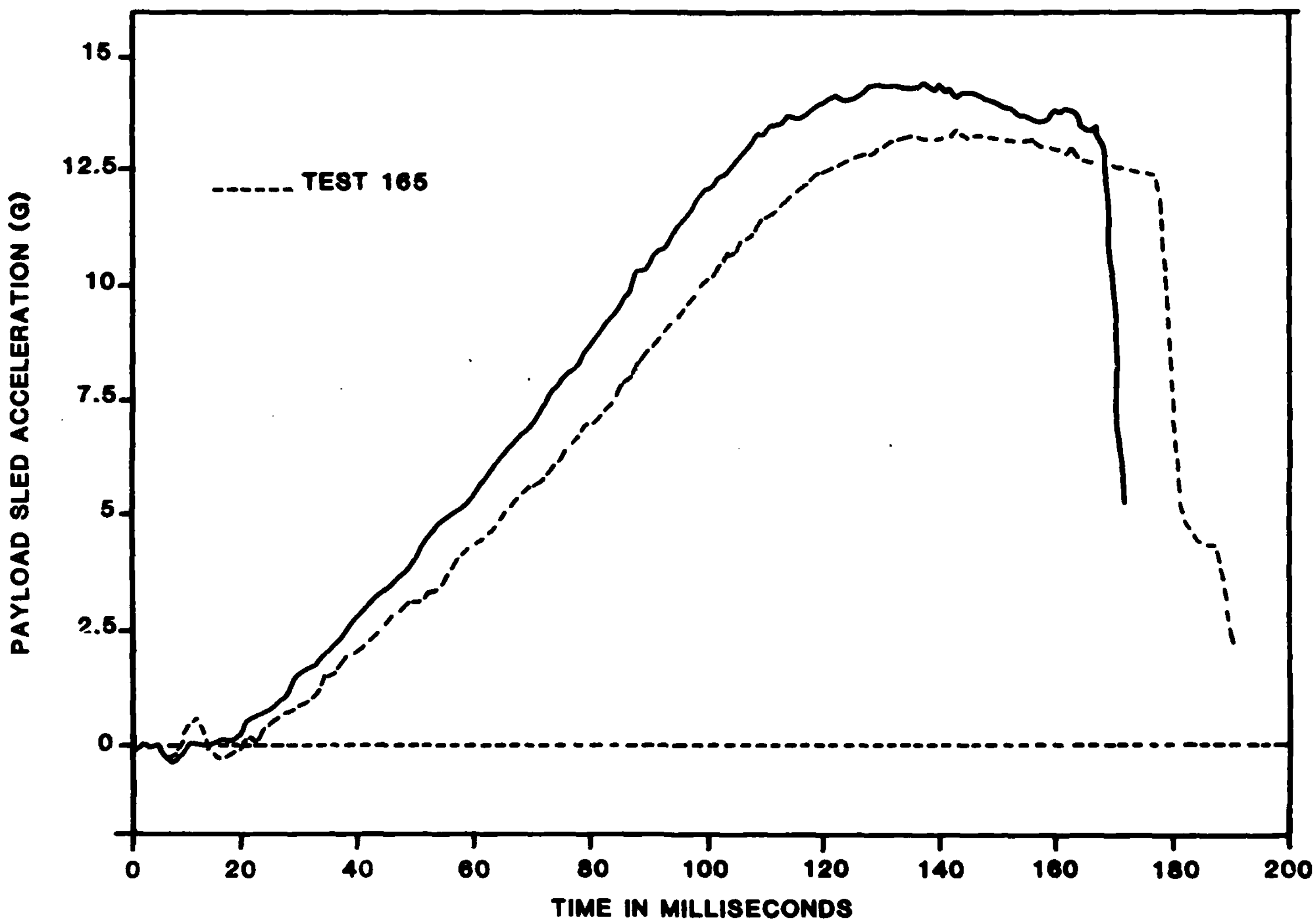

Figure 4. Catapult Acceleration Test Data for Test Nos. 158 and 165

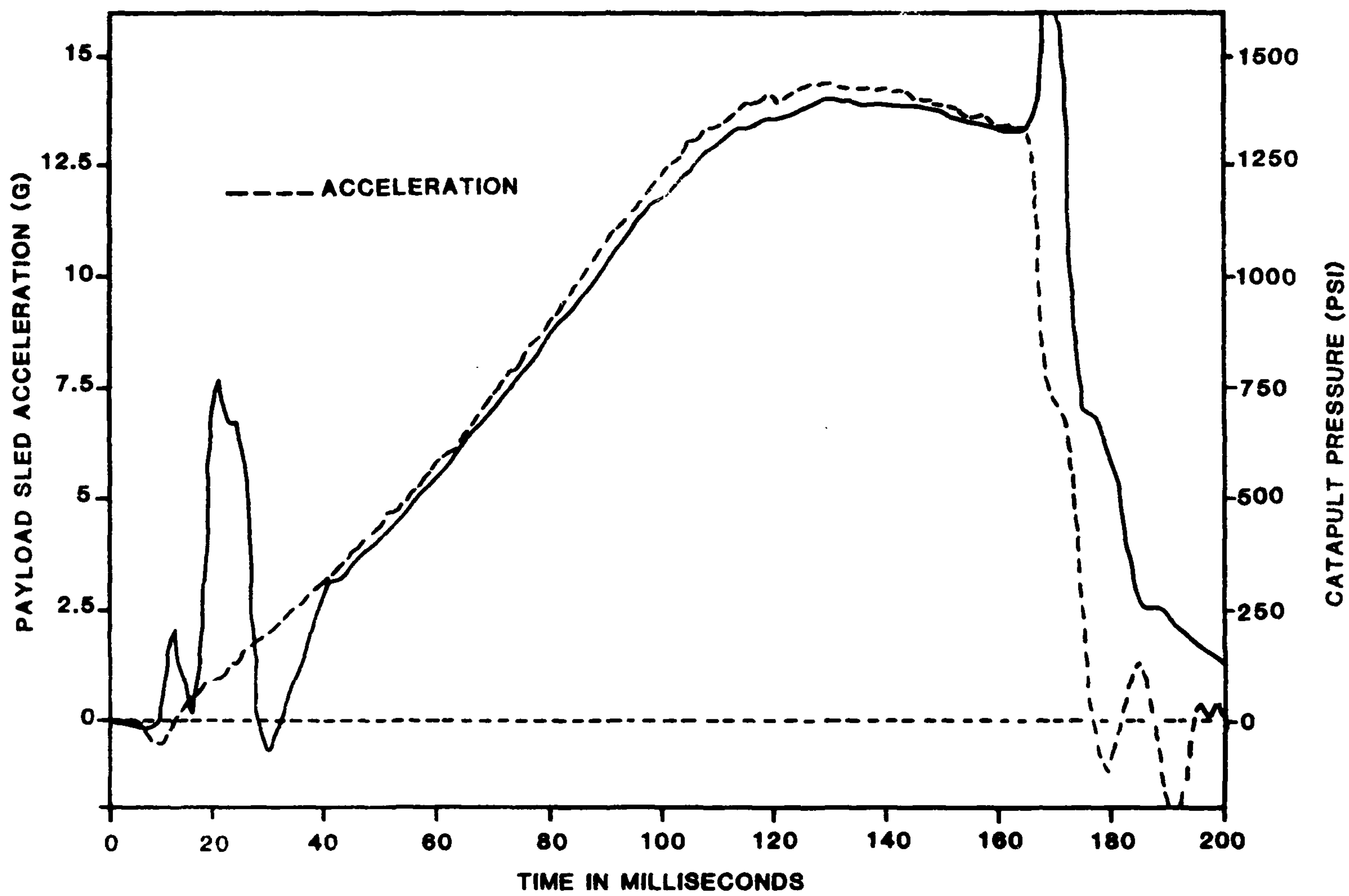

Figure 5. Acceleration of Payload Sled and Catapult Pressure versus Time for Test No. 164

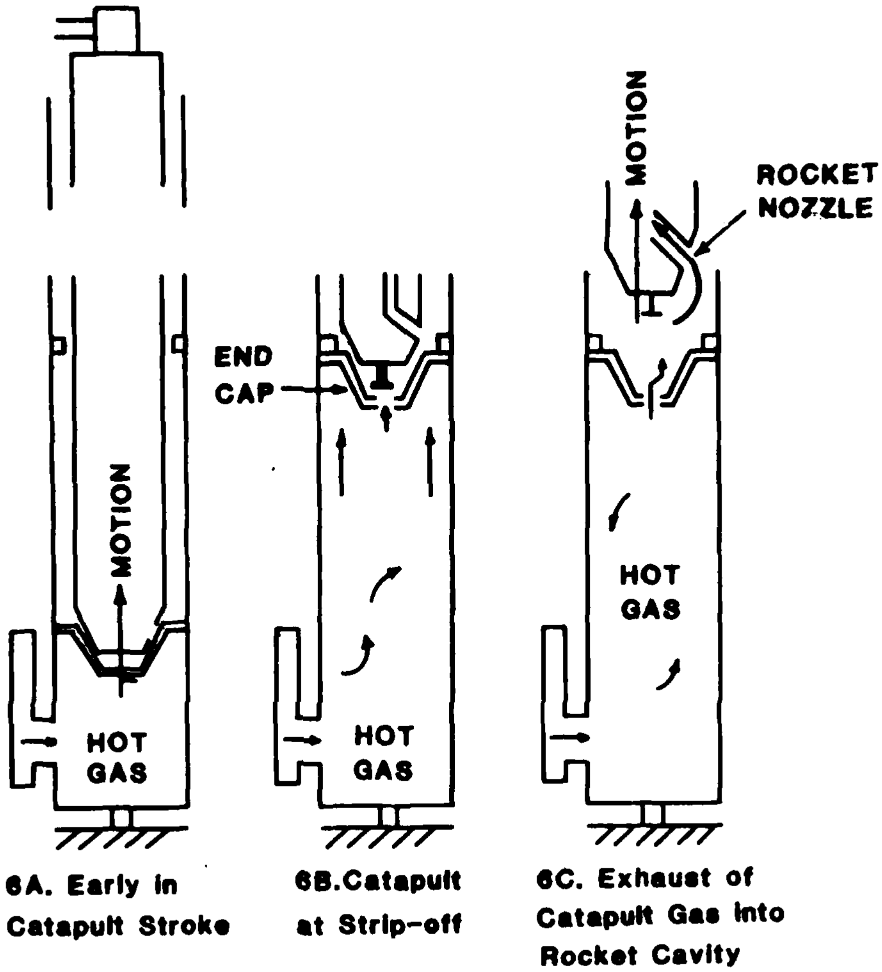

Figure 6. Separation of Internal Catapult Tube from Catapult End-Cap

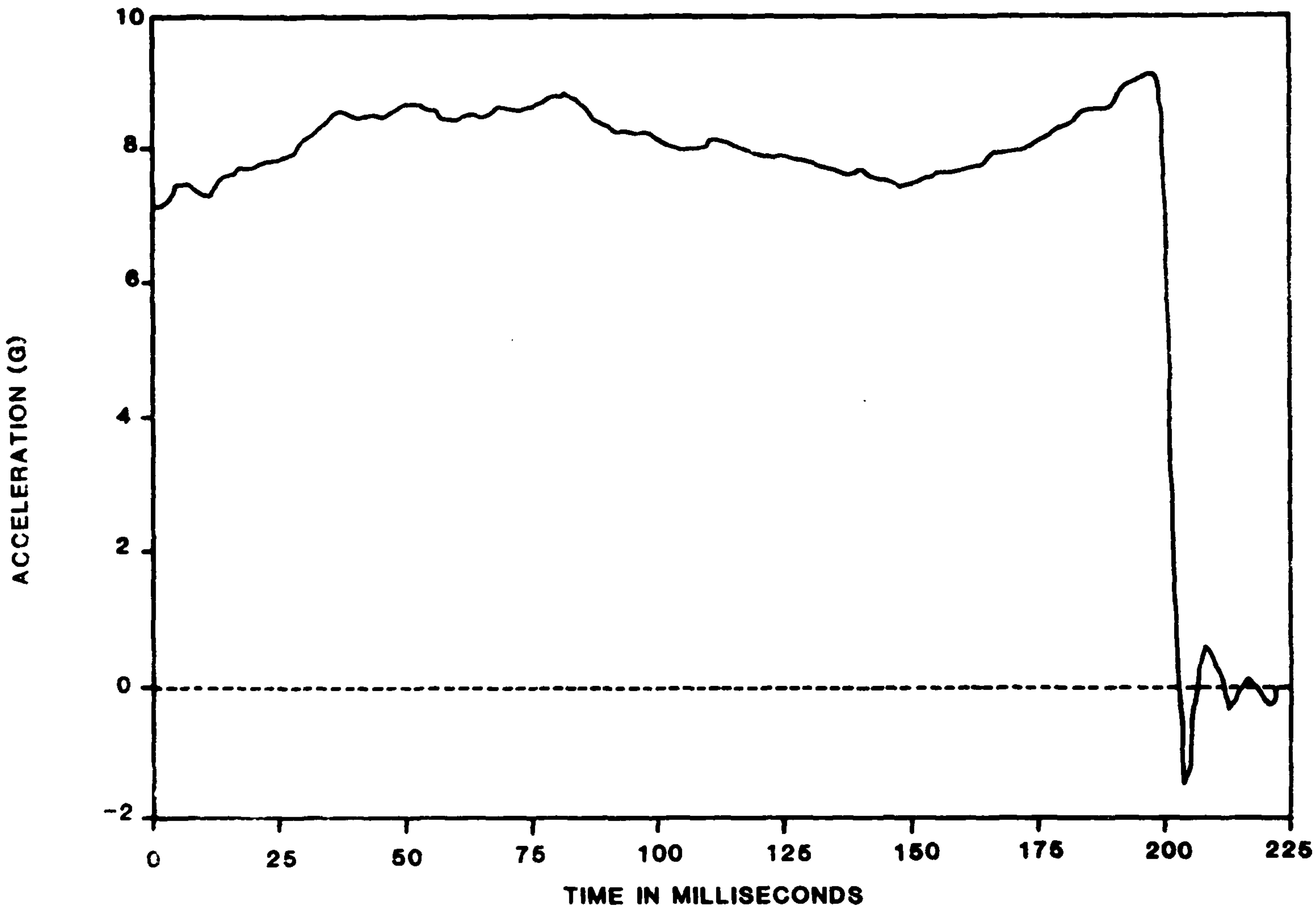

Figure 7. Carrier Sled Acceleration for Test No. 183 in Gs

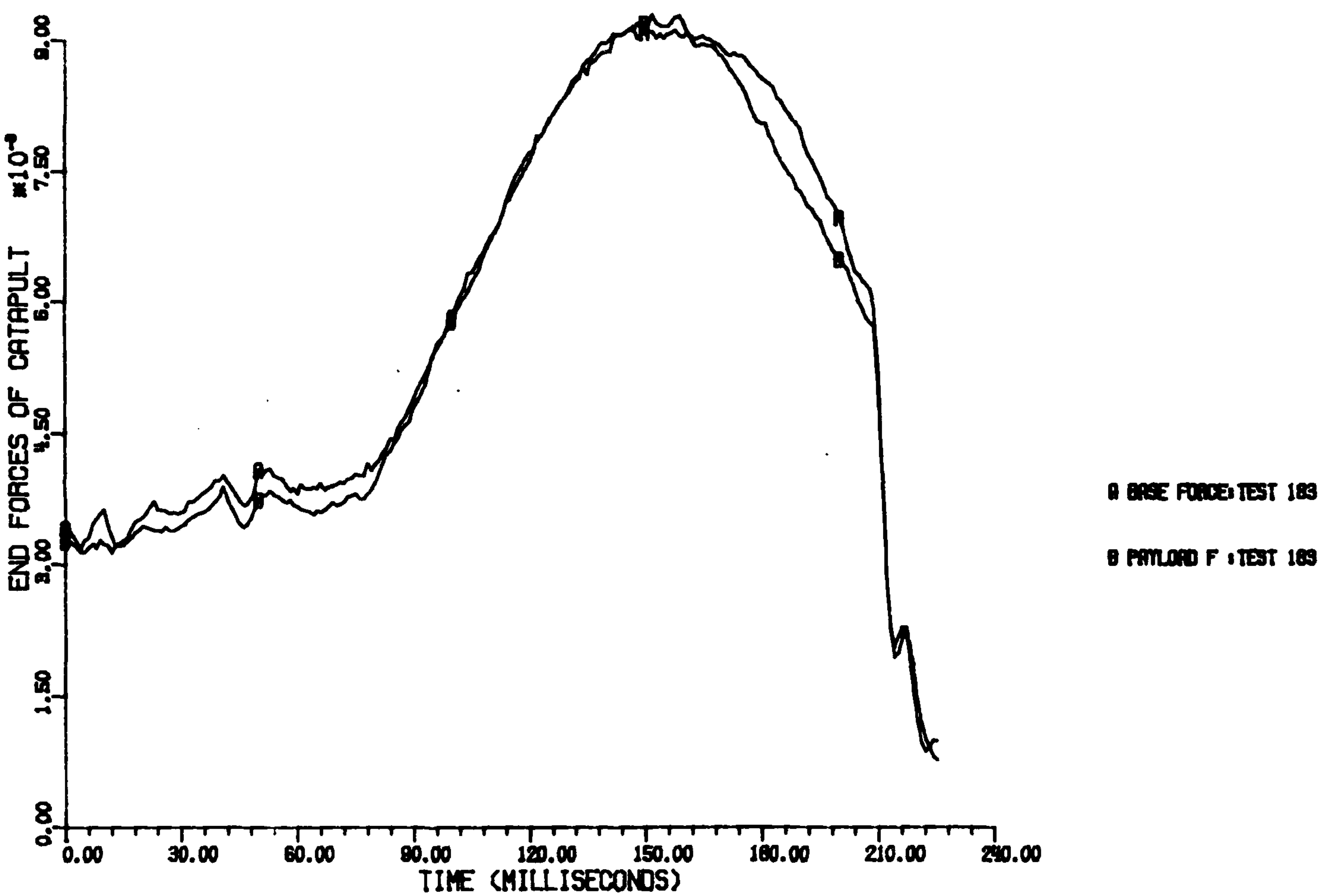

Figure 8. Force Transducer Output at Opposite Ends of Catapult

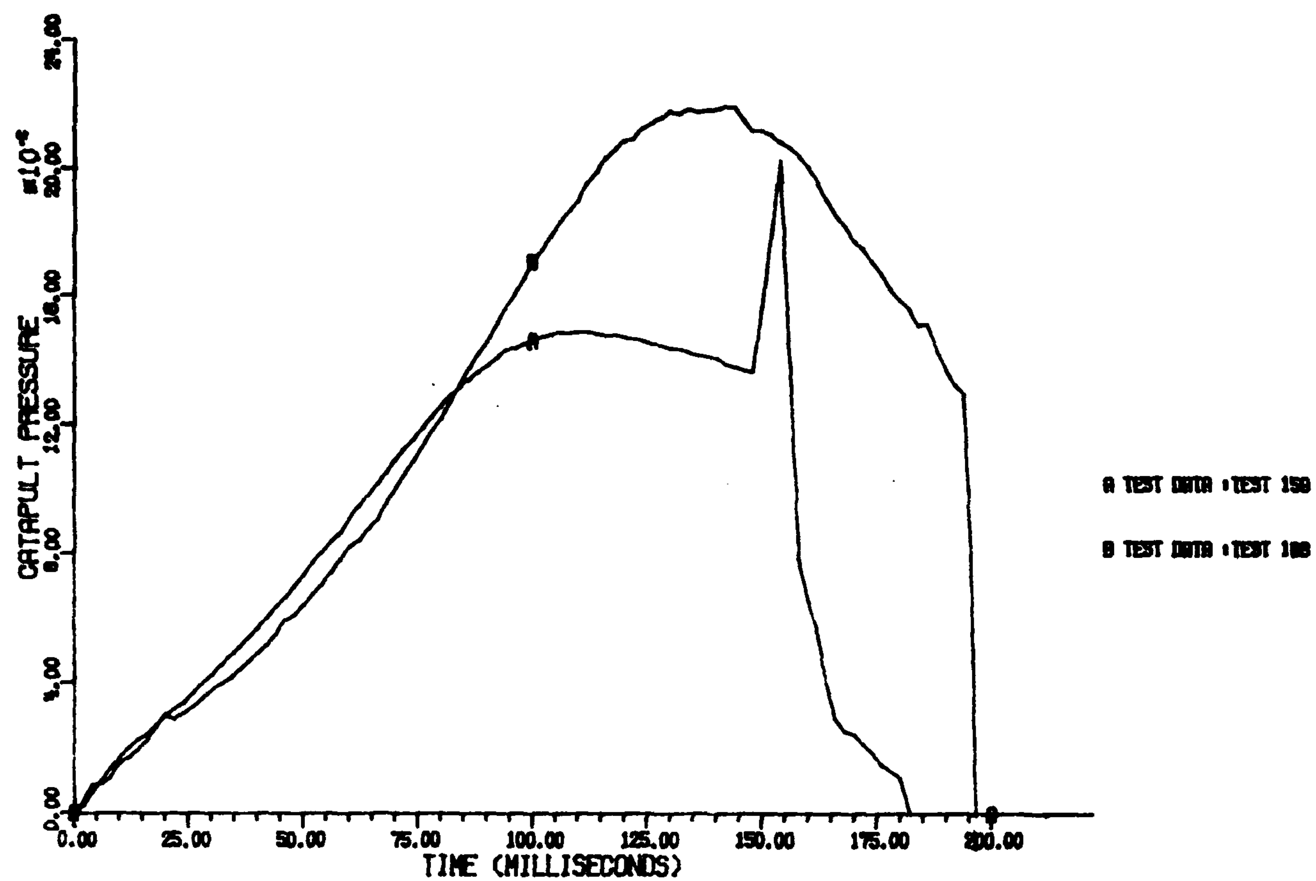

Figure 9. Pressure Comparison between Static Test (Test No. 159) and High-G Test (Test No. 183)

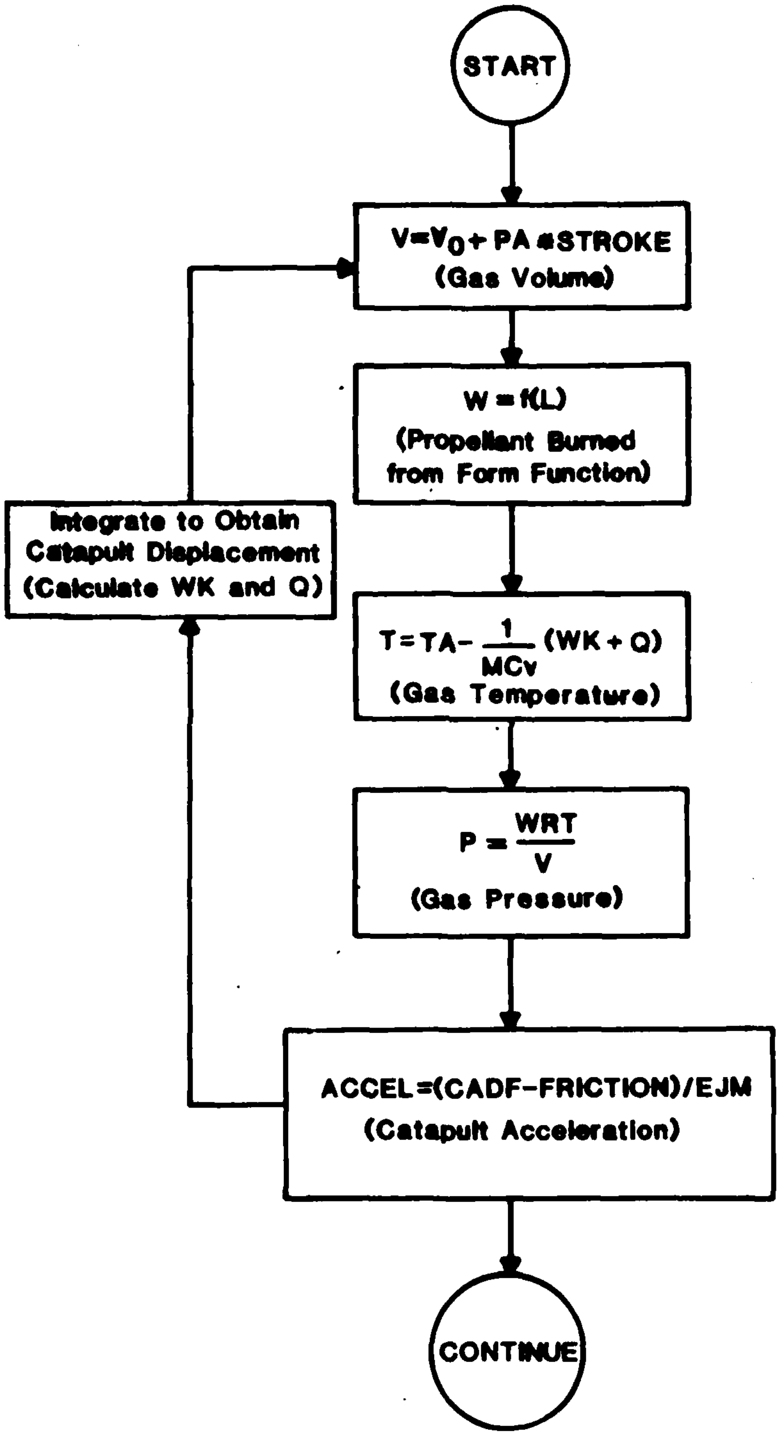

Figure 10. Logic Flow Diagram for a Known Propellant Form Function

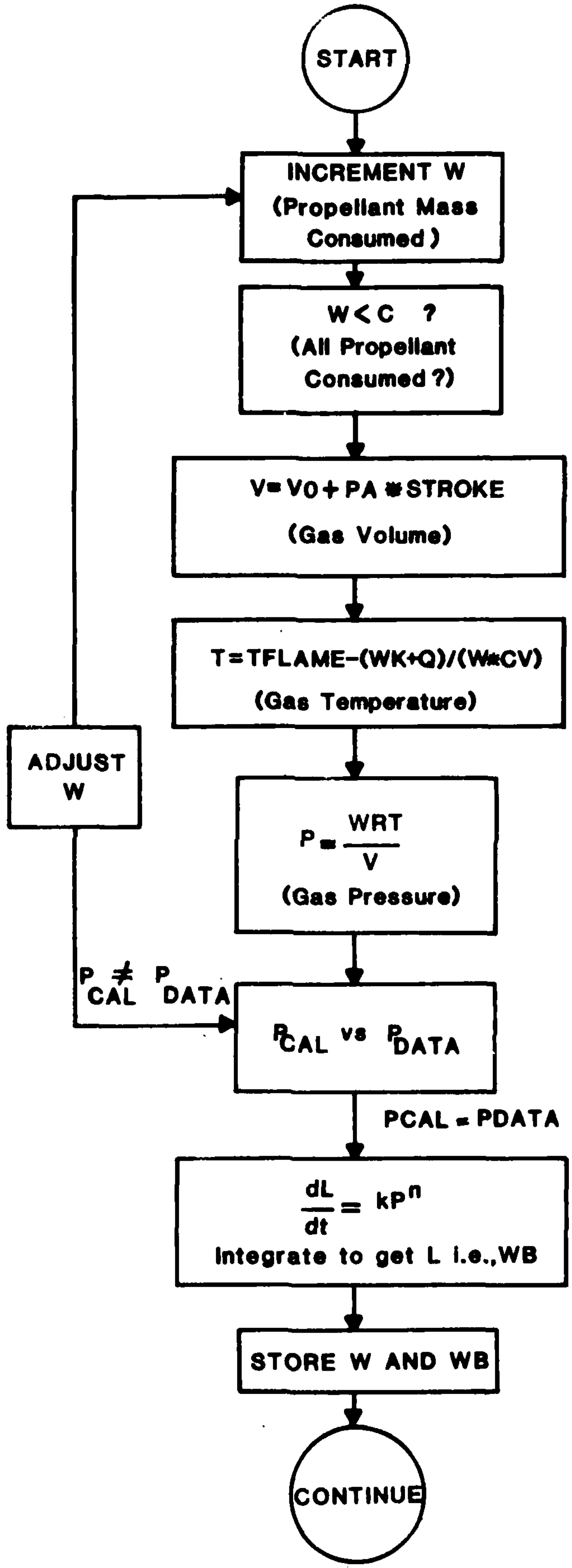

Figure 11. Logic Flow Diagram for Calculation of Propellant Form Function with Known Catapult Pressure

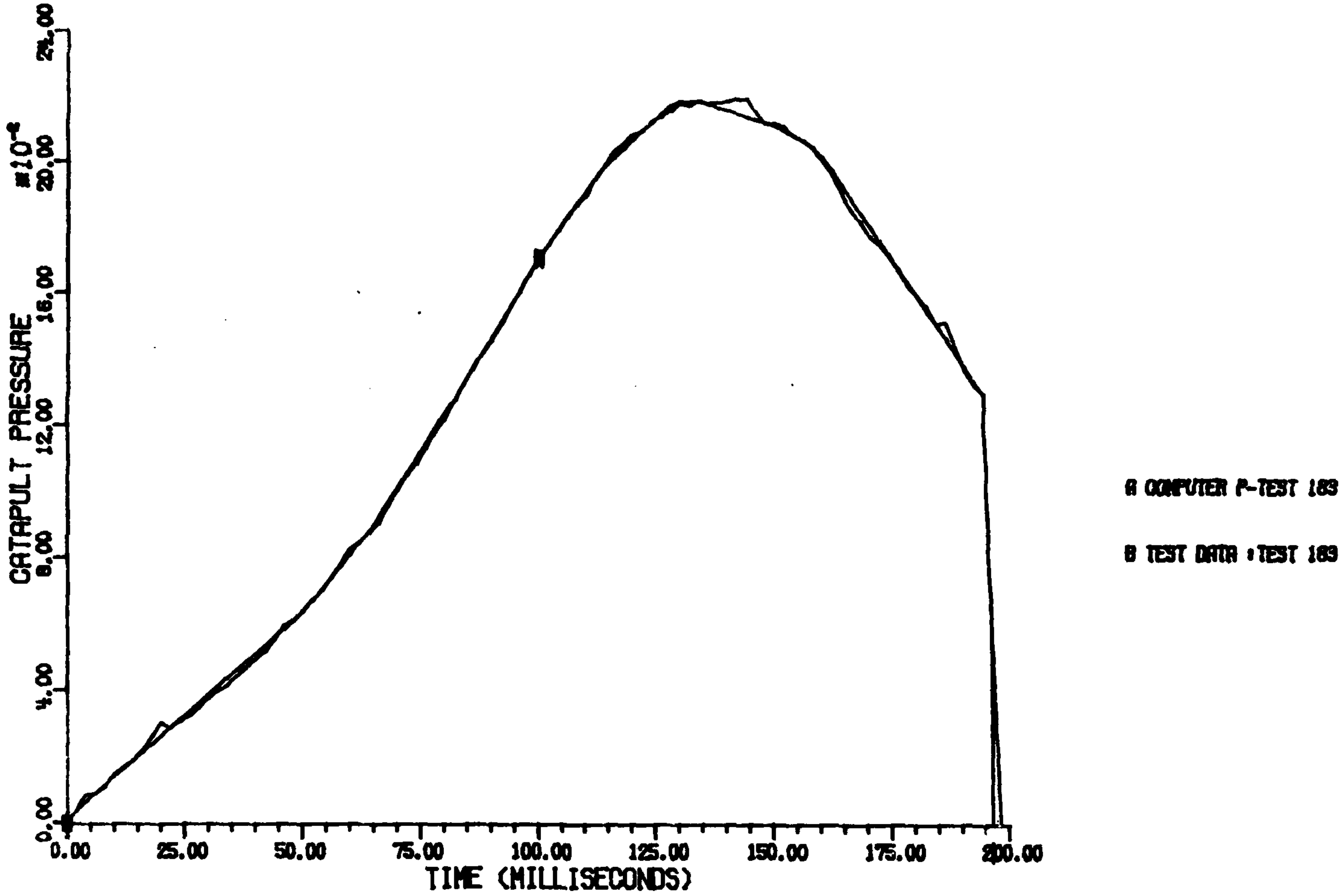

Figure 12. A Comparison of the Actual Catapult Pressure-Time Curve to the Pressure-Time Curve Generated by the Computer Model (Test No. 183)

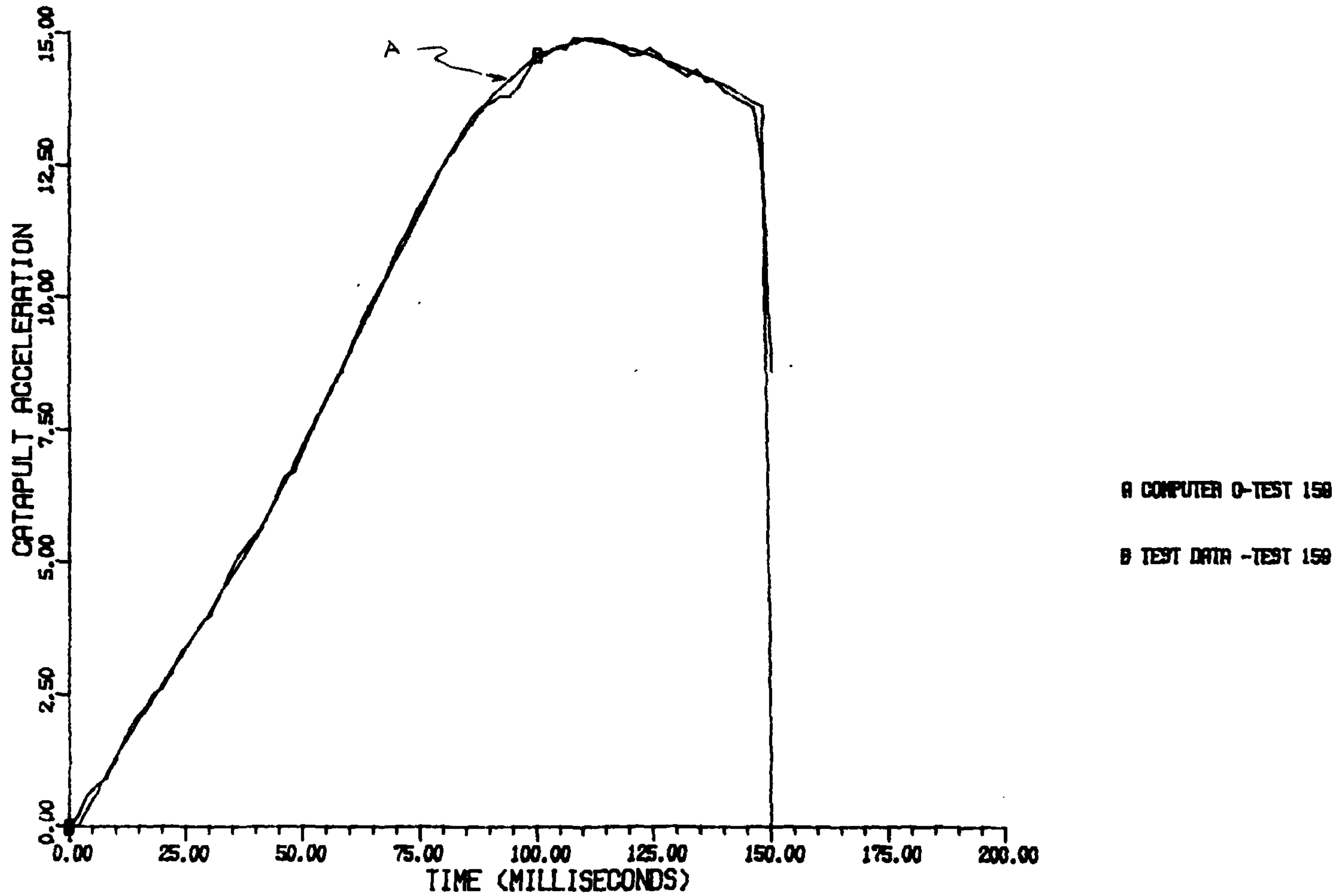

Figure 13. A Comparison of the Actual Catapult Acceleration with the Acceleration Generated by the Computer Model (Test No. 159)

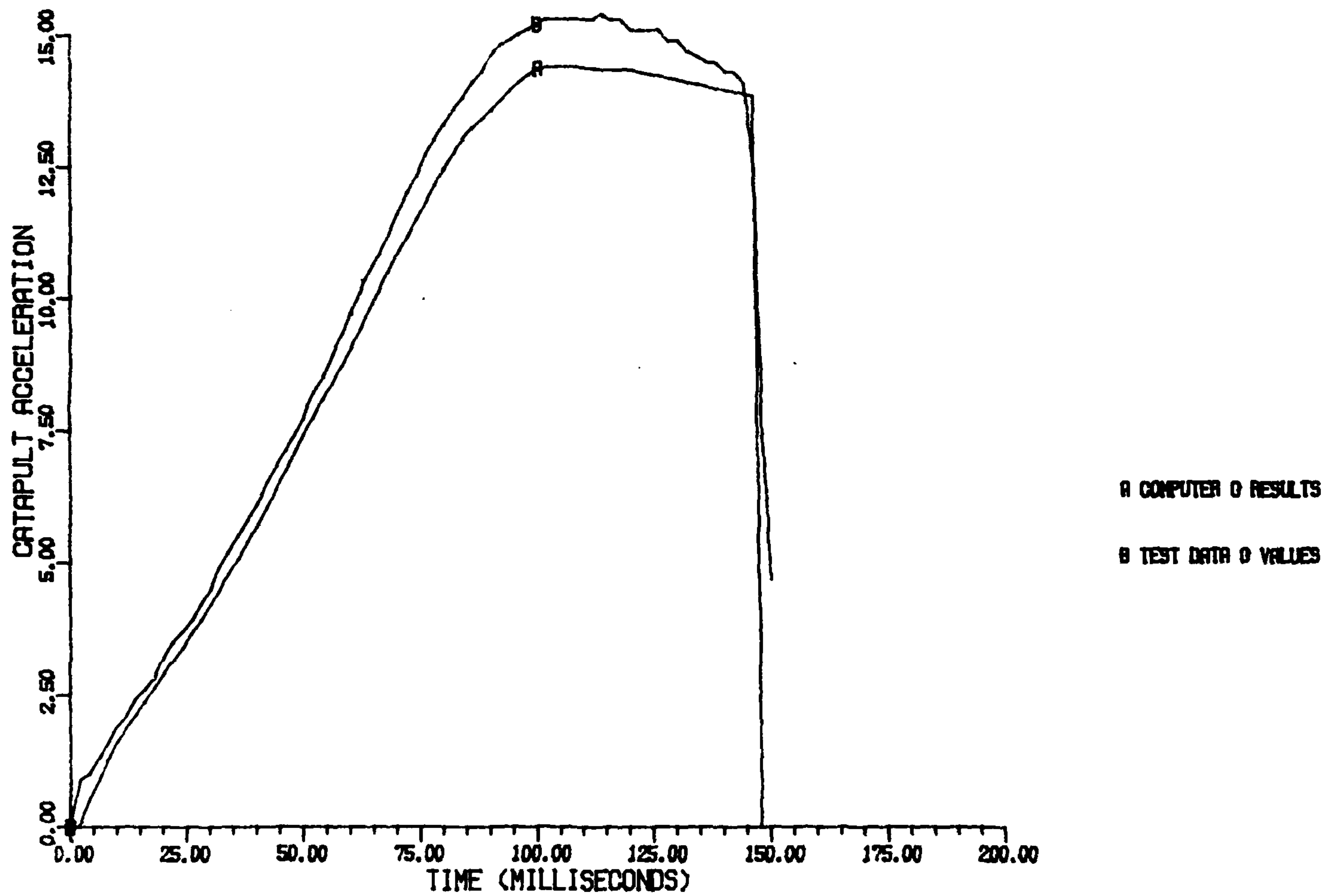

Figure 14. A Comparison of the Actual Catapult Acceleration with the Acceleration Generated by the Computer Model. Friction Coefficients Used Here Were Determined from Test No. 159 Data.

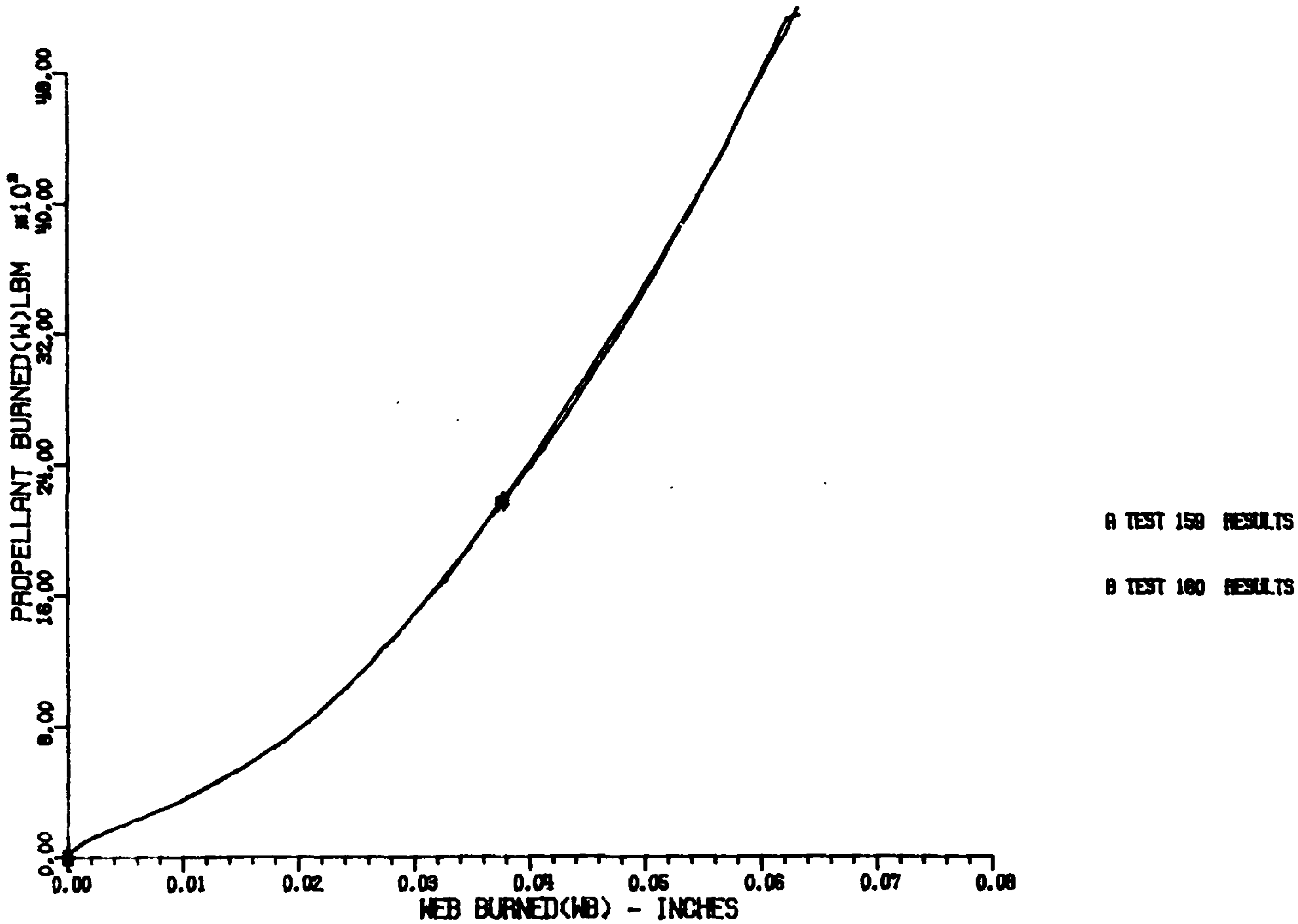

Figure 15. Form Function Comparison for Test Nos. 159 and 160

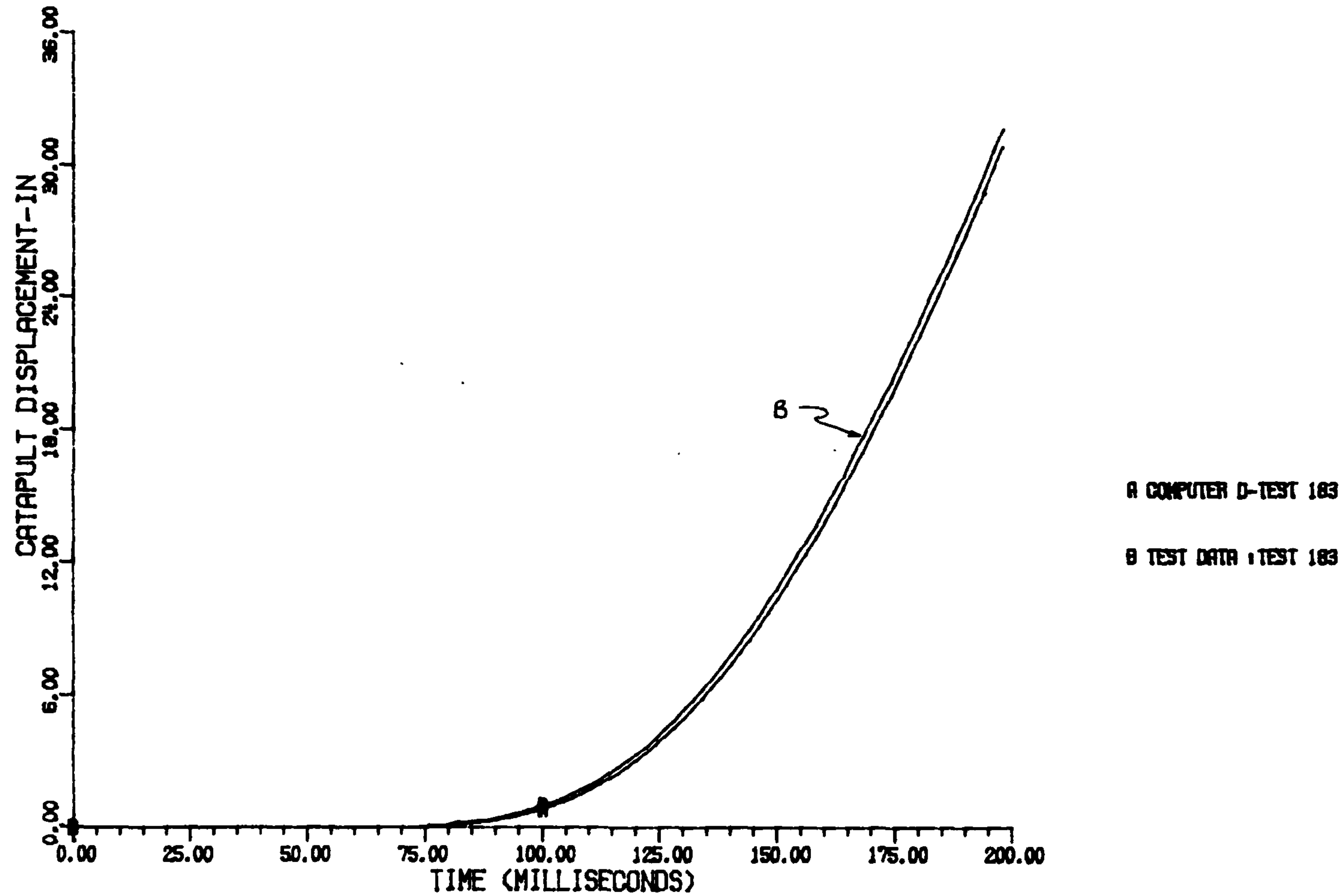

Figure 16. Catapult Displacement versus Time for Test No. 183

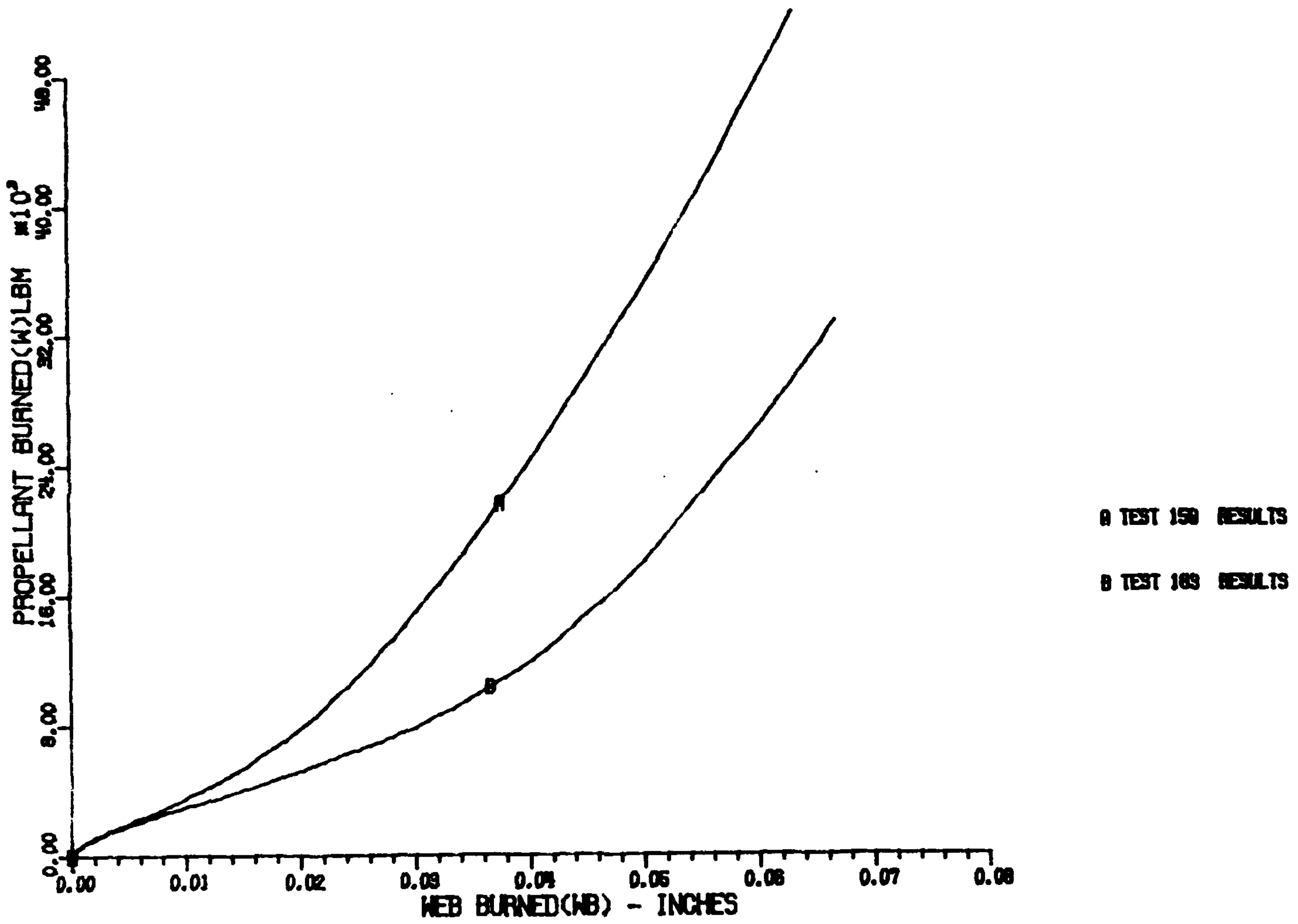

Figure 17. Form Function Comparison for Test Nos. 159 and 183

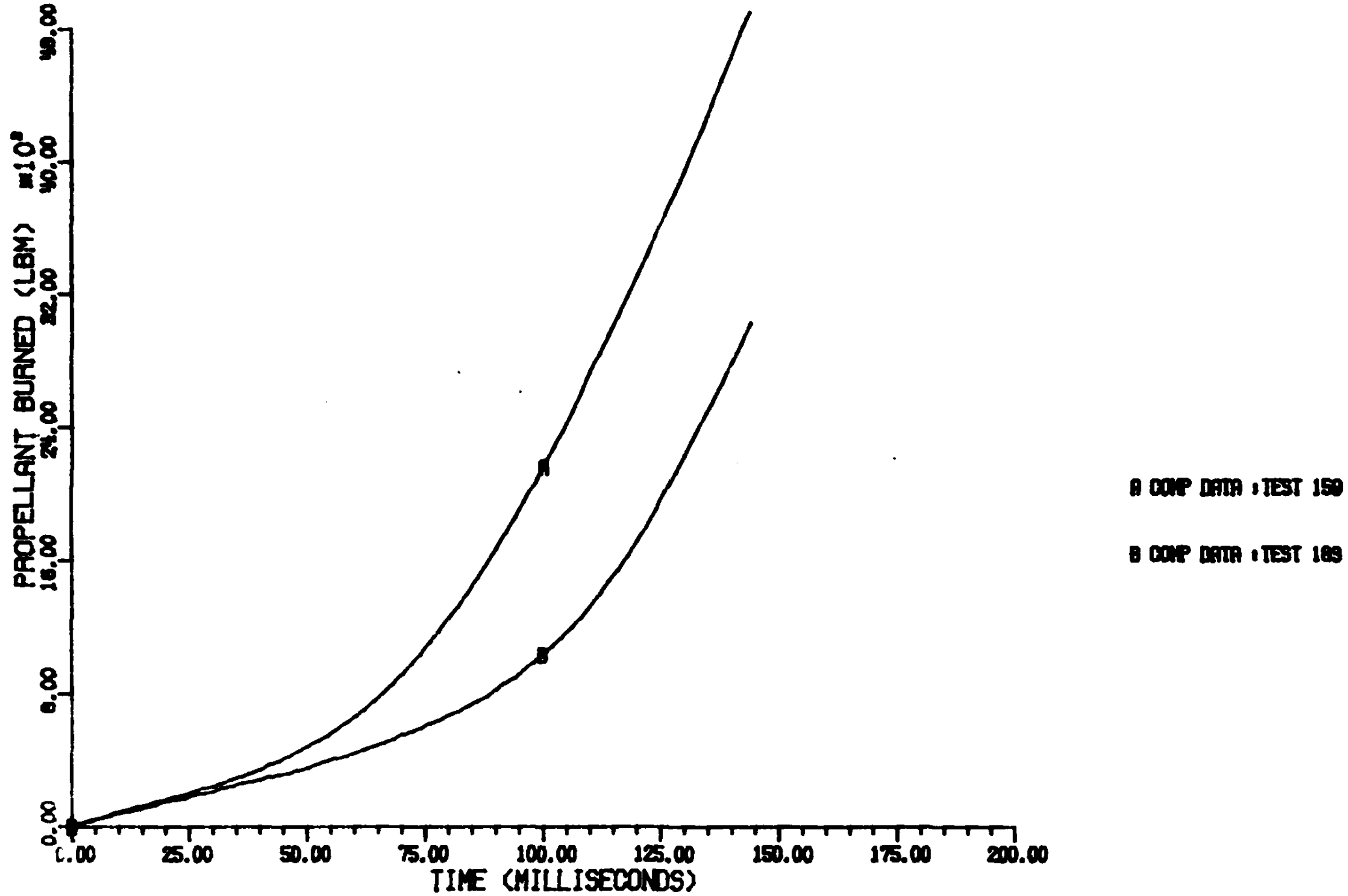

Figure 18. Calculated Value of Propellant Consumed versus Time for Test Nos. 159 and 183

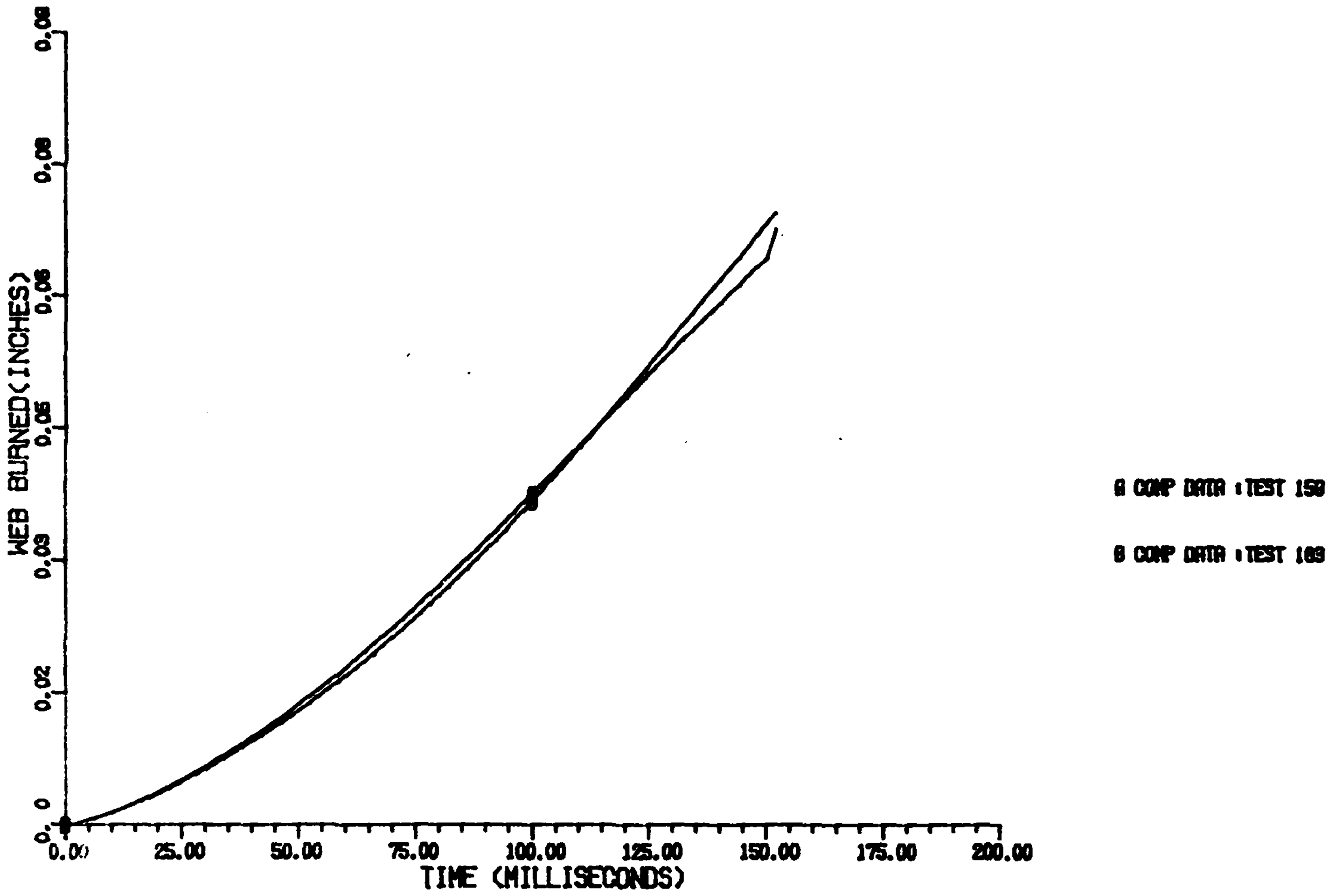

Figure 19. Calculated Values of Web Burned versus Time for Test Nos. 159 and 183.

APPENDIX A

Digitized Data Set for Test 159

TEST: 159AAA PAYLOAD SLED DISP IN INCHESAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5
0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.1
1.1	1.2	1.3	1.4	1.5	1.5	1.6	1.7	1.8	1.9
2.0	2.1	2.2	2.3	2.4	2.5	2.7	2.8	2.9	3.1
3.2	3.3	3.5	3.6	3.8	4.0	4.1	4.3	4.5	4.6
4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.5	6.7
6.9	7.2	7.4	7.7	7.9	8.2	8.5	8.7	9.0	9.3
9.6	9.9	10.2	10.5	10.8	11.1	11.4	11.8	12.1	12.4
12.8	13.1	13.5	13.9	14.2	14.6	15.0	15.4	15.8	16.2
16.6	17.0	17.4	17.8	18.3	18.7	19.1	19.6	20.0	20.5
20.9	21.4	21.9	22.3	22.8	23.3	23.8	24.3	24.8	25.3
25.8	26.4	26.9	27.4	28.0	28.5	29.0	29.6	30.1	30.7
31.3	31.8	32.4	33.0	33.5	34.1	34.7	35.3	35.8	36.4
37.0	37.6	38.2	38.7	39.3	39.9	40.5	41.0	41.6	42.2
42.8	43.4	43.9	44.5	45.1	45.7	46.3	46.8	47.4	48.0

48.6AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

TEST: 159AAA CATAPULT PRESSURE IN PSIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

1.2	-0.5	1.2	1.2	-2.3	-0.5	4.7	20.4	27.4	8.2
-30.2	-49.4	-52.9	-42.4	-25.0	-14.5	-11.0	-11.0	-11.0	-7.5
6.4	22.2	44.9	62.3	85.0	99.0	116.4	135.6	149.6	165.3
181.0	198.5	214.2	222.9	233.4	240.4	256.1	268.3	284.0	294.5
310.2	318.9	322.4	338.1	353.8	367.8	378.3	395.7	414.9	423.7
441.1	453.3	470.8	483.0	493.5	510.9	524.9	540.6	556.3	566.8
584.3	598.2	619.2	634.9	659.3	662.8	683.8	697.7	716.9	730.9
751.8	771.0	792.0	802.5	823.4	839.1	858.3	865.3	889.8	910.7
929.9	947.3	966.5	980.5	998.0	1015.4	1034.6	1050.3	1071.3	1088.8
1106.2	1123.7	1139.4	1153.3	1174.3	1191.7	1209.2	1223.2	1249.3	1256.3
1279.0	1289.5	1300.0	1313.9	1327.9	1340.1	1354.1	1362.8	1385.5	1383.8
1401.2	1404.7	1416.9	1432.6	1434.4	1439.6	1453.6	1450.1	1464.1	1460.6
1465.8	1472.8	1478.0	1478.0	1478.0	1486.8	1490.2	1485.0	1499.0	1488.5
1492.0	1488.5	1486.8	1481.5	1483.3	1478.0	1478.0	1479.8	1479.8	1472.8
1472.8	1467.6	1465.8	1462.3	1458.8	1451.8	1453.6	1448.3	1446.6	1439.6
1434.4	1436.1	1429.2	1425.7	1422.2	1416.9	1416.9	1411.7	1404.7	1406.4
1396.0	1390.7	1389.0	1382.0	1378.5	1371.5	1366.3	1366.3	1429.2	1551.3
1635.1	1788.8	1977.3	2020.9	1797.5	1406.4	1022.4	786.8	690.7	659.3
624.4	566.8	483.0	401.0	338.1	291.0	261.3	252.6	247.4	243.9
229.9	212.4	193.2	186.3	161.8	151.3	144.4	132.1	118.2	109.4

100.7AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

TEST: 159AAA PAYLOAD FORCE IN LBSAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

-7.3	-22.0	-7.3	-22.0	-22.0	-14.6	-7.3	22.3	29.7	-96.1
-273.6	-362.5	-288.5	-192.3	-103.4	-29.5	-14.6	-22.0	-36.8	-44.3
29.7	88.9	140.7	229.5	318.3	355.3	421.9	473.7	562.5	569.9
666.1	688.3	769.7	828.9	873.3	932.5	984.3	1028.7	1102.7	1124.9
1213.7	1221.1	1302.5	1324.7	1376.5	1435.7	1472.7	1517.1	1620.7	1642.9
1702.1	1768.7	1835.3	1879.7	1938.9	1990.7	2049.9	2123.9	2168.3	2227.5
2286.7	2338.5	2382.9	2442.1	2486.5	2545.7	2619.7	2693.7	2738.1	2856.5
2923.1	2982.3	3034.1	3115.5	3167.3	3248.7	3293.1	3367.1	3433.7	3485.5
3552.1	3618.7	3707.5	3766.7	3833.3	3899.9	3944.3	4025.7	4092.3	4144.1
4225.5	4277.3	4343.9	4380.9	4469.7	4528.9	4588.1	4632.5	4691.7	4736.1
4795.3	4847.1	4913.7	4980.3	5002.5	5039.5	5113.5	5150.5	5209.7	5254.1
5283.7	5320.7	5350.3	5379.9	5416.9	5453.9	5439.1	5483.5	5505.7	5527.9
5535.3	5572.3	5564.9	5594.5	5601.9	5616.7	5616.7	5638.9	5631.5	5638.9
5631.5	5646.3	5638.9	5646.3	5638.9	5631.5	5638.9	5653.7	5631.5	5631.5
5646.3	5624.1	5609.3	5601.9	5579.7	5564.9	5550.1	5572.3	5527.9	5520.5
5498.3	5498.3	5490.9	5468.7	5431.7	5439.1	5394.7	5387.3	5372.5	5342.9
5328.1	5335.5	5276.3	5283.7	5254.1	5246.7	5187.5	4861.9	4218.1	3478.1
2974.9	2797.3	2738.1	2634.5	2353.3	1916.7	1302.5	725.3	370.1	222.1
214.7	273.9	236.9	177.7	51.9	-66.4	-118.3	-155.3	-110.8	-36.8
29.7	59.3	74.1	88.9	74.1	51.9	51.9	37.1	66.7	51.9

66.7AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

TEST: 159AAA BASE FORCE IN LBSAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

-6.2	-35.6	-6.2	-6.2	-13.5	-28.3	1.2	30.6	67.4	-43.0
-197.6	-249.1	-227.0	-160.8	-28.3	30.6	45.3	38.0	23.3	15.9
52.7	104.2	185.2	280.9	339.8	428.1	479.6	531.2	575.3	604.8
663.7	715.2	774.1	847.7	891.8	958.1	958.1	1024.3	1075.9	1127.4
1178.9	1215.7	1259.9	1318.8	1362.9	1414.5	1451.3	1524.9	1561.7	1605.8
1657.4	1738.3	1775.1	1834.0	1870.8	1922.4	1988.6	2047.5	2099.0	2194.7
2216.8	2261.0	2327.2	2386.1	2422.9	2525.9	2577.5	2643.7	2680.5	2761.5
2813.0	2894.0	2975.0	3019.1	3085.4	3159.0	3217.9	3284.1	3343.0	3416.6
3482.9	3541.8	3600.6	3718.4	3762.6	3806.8	3865.6	3931.9	3990.8	4057.0
4115.9	4219.0	4241.0	4299.9	4351.5	4395.6	4491.3	4550.2	4579.6	4623.8
4668.0	4741.6	4778.4	4829.9	4888.8	4925.6	4991.9	5021.3	5087.5	5117.0
5146.4	5175.9	5205.3	5242.1	5264.2	5293.6	5293.6	5323.1	5323.1	5352.5
5382.0	5389.3	5411.4	5433.5	5448.2	5448.2	5448.2	5462.9	5477.7	5492.4
5492.4	5492.4	5470.3	5470.3	5485.0	5470.3	5492.4	5485.0	5485.0	5470.3
5470.3	5470.3	5492.4	5483.5	5448.2	5440.9	5433.5	5440.9	5418.8	5418.8
5411.4	5389.3	5374.6	5374.6	5374.6	5345.2	5359.9	5323.1	5323.1	5301.0
5308.4	5293.6	5293.6	5264.2	5271.6	5249.5	5264.2	4933.0	4307.3	3637.4
3122.2	2820.4	2746.8	2761.5	2636.4	2386.1	2032.8	1664.7	1326.1	1186.3
1017.0	766.7	560.6	295.6	148.4	30.6	52.7	74.8	170.5	236.7
280.9	317.7	303.0	273.5	266.2	244.1	214.6	214.6	199.9	192.6

163.1AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

TEST: 159AAA PAYLOAD SLED ACCEL IN GSAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	-0.3	-0.3
-0.3	-0.2	-0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.2	0.4	0.6	0.7	0.8	0.9	0.9	1.1	1.3
1.4	1.7	1.8	2.0	2.1	2.2	2.4	2.5	2.5	2.6
2.8	2.9	3.1	3.3	3.4	3.5	3.6	3.8	3.9	4.0
4.2	4.3	4.4	4.7	4.9	5.1	5.2	5.3	5.4	5.5
5.6	5.8	6.0	6.2	6.3	6.6	6.7	6.7	6.9	7.1
7.3	7.5	7.7	7.9	8.1	8.2	8.4	8.6	8.8	9.0
9.1	9.4	9.6	9.8	9.9	10.1	10.3	10.4	10.7	10.9
11.1	11.2	11.5	11.6	11.8	11.9	12.0	12.2	12.3	12.5
12.6	12.8	13.0	13.1	13.3	13.4	13.5	13.6	13.7	13.7
13.9	13.8	13.8	13.8	13.9	14.0	14.2	14.3	14.7	14.6
14.6	14.6	14.7	14.7	14.7	14.7	14.8	14.9	14.9	14.9
15.1	14.9	14.9	14.9	14.8	14.8	14.8	14.7	14.8	14.6
14.6	14.6	14.7	14.7	14.8	14.6	14.5	14.4	14.3	14.3
14.2	14.2	14.2	14.3	14.2	14.1	14.1	14.1	14.0	13.9
13.8	13.8	13.7	13.7	13.7	13.6	13.5	12.6	10.8	8.6
6.4	4.5	3.5	3.5	4.1	4.9	5.0	4.1	2.7	0.3
-2.1	-3.2	-2.8	-1.2	0.6	2.0	2.5	2.4	1.8	0.9
0.4	0.7	1.0	1.0	0.3	0.0	0.2	0.5	0.6	0.4
0.1									

0.1AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

TEST: 159AAA PAYLOAD SLED VEL IN FT/SECAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2
0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.8	0.9
0.9	1.0	1.1	1.2	1.3	1.5	1.6	1.7	1.8	1.9
2.1	2.2	2.3	2.5	2.7	2.8	3.0	3.1	3.3	3.5
3.7	3.9	4.1	4.3	4.4	4.7	4.9	5.1	5.3	5.5
5.8	6.0	6.3	6.5	6.8	7.0	7.3	7.6	7.8	8.1
8.4	8.7	9.0	9.4	9.7	10.0	10.3	10.6	11.0	11.3
11.7	12.1	12.4	12.8	13.2	13.5	13.9	14.3	14.7	15.1
15.5	15.9	16.3	16.8	17.2	17.6	18.0	18.5	18.9	19.4
19.8	20.3	20.7	21.1	21.6	22.0	22.5	23.0	23.4	23.9
24.4	24.8	25.3	25.8	26.3	26.7	27.2	27.7	28.1	28.6
29.1	29.6	30.1	30.6	31.0	31.5	32.0	32.5	32.9	33.4
33.9	34.4	34.8	35.3	35.8	36.3	36.7	37.2	37.7	38.1
38.6	39.0	39.5	40.0	40.4	40.9	41.3	41.8	42.2	42.7
43.1	43.6	44.0	44.5	44.9	45.3	45.8	46.2	46.6	46.9
47.1	47.3	47.4	47.5	47.7	47.8	48.0	48.1	48.2	48.3
48.3	48.2	48.1	48.0	48.0	48.0	48.1	48.2	48.3	48.3
48.3	48.3	48.4	48.4	48.4	48.4	48.4	48.4	48.5	48.5

48.5AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

APPENDIX B

Digitized Data Set for Test 183

TEST: 183 CATAPULT PRESSURE IN PSIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

-30.1	-23.2	-23.2	-26.6	-19.8	-9.5	-9.5	42.0	52.3	55.8
31.7	-12.9	-43.8	-64.4	-57.5	-33.5	4.3	38.6	59.2	86.7
79.8	90.1	93.5	107.3	127.9	148.5	155.3	169.1	182.8	189.7
203.4	220.6	230.9	261.8	268.6	303.0	289.2	289.2	299.5	306.4
313.3	323.6	333.9	347.6	351.0	375.1	381.9	395.7	406.0	412.8
436.9	440.3	454.0	464.3	474.6	491.8	495.2	515.8	539.9	550.2
574.2	594.8	608.5	608.5	618.8	639.4	656.6	673.8	697.8	701.2
721.8	739.0	759.6	780.2	800.8	824.8	828.3	842.0	855.8	876.3
893.5	903.8	938.2	955.3	975.9	1003.4	1020.6	1048.0	1068.6	1085.8
1109.8	1130.4	1151.0	1178.5	1199.1	1216.3	1247 2	1271.2	1291.8	1322.7
1350.2	1374.2	1398.2	1418.8	1436.0	1456.6	1487.5	1504.7	1528.7	1559.6
1580.2	1604.2	1631.7	1652.3	1679.8	1707.3	1738.2	1745.0	1772.5	1789.7
1806.8	1834.3	1851.4	1868.6	1892.7	1896.1	1933.9	1954.5	1971.6	1988.8
2006.0	2033.4	2033.4	2057.5	2071.2	2084.9	2091.8	2091.8	2109.0	2126.1
2136.4	2139.9	2157.0	2157.0	2187.9	2181.1	2174.2	2174.2	2187.9	2187.9
2187.9	2181.1	2181.1	2184.5	2184.5	2187.9	2187.9	2194.8	2201.7	2194.8
2177.6	2153.6	2136.4	2119.3	2119.3	2119.3	2119.3	2109.0	2095.2	2084.9
2071.2	2067.8	2067.8	2043.7	2040.3	2006.0	1985.4	1961.3	1930.4	1906.4
1892.7	1854.9	1848.0	1820.6	1796.5	1775.9	1755.3	1751.9	1731.3	1714.1
1693.5	1672.9	1652.3	1624.8	1607.7	1590.5	1566.5	1563.0	1532.1	1508.1
1504.7	1511.5	1463.5	1439.4	1405.1	1370.8	1336.4	1326.1	1305.5	1295.2
1192.2	581.1	-675.6	-2217.2	-2745.9	-2745.9	-2745.9	-2745.9	-2745.9	-2745.9
-2745.9	-2745.9	-2745.9	-2745.9	-2745.9	-2745.9AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA				

TEST: 183 PAYLOAD FORCE IN LBSAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

3268.1	3268.1	3238.5	3208.9	3149.7	3149.7	3194.1	3238.5	3194.1	3282.9
3238.5	3223.7	3149.7	3223.7	3223.7	3223.7	3268.1	3312.5	3371.8	3401.4
3445.8	3431.0	3416.2	3401.4	3401.4	3386.6	3431.0	3401.4	3401.4	3416.2
3445.8	3475.4	3519.8	3549.4	3579.1	3593.9	3608.7	3638.3	3682.7	3727.1
3786.3	3890.0	3727.1	3653.1	3564.2	3475.4	3431.0	3460.6	3534.6	3653.1
3741.9	3801.1	3801.1	3845.6	3801.1	3786.3	3741.9	3712.3	3741.9	3682.7
3667.9	3638.3	3623.5	3608.7	3579.1	3623.5	3608.7	3638.3	3667.9	3712.3
3682.7	3697.5	3727.1	3786.3	3801.1	3816.0	3756.7	3756.7	3816.0	3860.4
3919.6	4038.1	4141.7	4260.2	4289.8	4378.6	4437.8	4541.5	4585.9	4630.3
4793.2	4867.2	4956.1	5044.9	5222.6	5355.9	5503.9	5563.1	5607.6	5696.4
5770.4	5874.1	5948.1	6037.0	6111.0	6214.6	6303.5	6377.5	6525.6	6629.2
6718.0	6821.7	6895.7	7014.2	7147.5	7177.1	7280.7	7354.7	7443.6	7532.4
7606.5	7710.1	7843.4	7902.6	7991.4	8065.5	8154.3	8228.3	8302.4	8346.8
8406.0	8480.0	8539.3	8568.9	8717.0	8761.4	8791.0	8850.2	8909.4	8968.7
8968.7	8998.3	9072.3	9072.3	9072.3	9087.1	9131.5	9116.7	9190.8	9161.2
9190.8	9176.0	9294.4	9205.6	9176.0	9176.0	9161.2	9205.6	9264.8	9279.6
9205.6	9087.1	9013.1	8939.0	8939.0	8953.8	8939.0	8939.0	8909.4	8835.4
8820.6	8731.8	8657.7	8598.5	8524.5	8465.2	8361.6	8257.9	8139.5	8065.5
8050.6	8050.6	7917.4	7843.4	7710.1	7636.1	7547.2	7473.2	7428.8	7310.3
7265.9	7191.9	7088.2	7058.6	6969.8	6925.4	6792.1	6703.3	6614.4	6555.2
6481.1	6421.9	6377.5	6259.0	6155.4	6007.3	5933.3	5814 9	5755.6	5711.2
4970.9	3934.4	2927.6	2305.7	2054.0	2172.4	2276.1	2187.2	1950.3	1565.3
1224.8	958.3	869.4	913.9	987.9	987.9AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA				

TEST: 183 PAYLOAD SLED VEL IN FPSAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

52.6	52.3	52.1	51.9	51.6	51.4	51.2	51.0	50.7	50.5
50.3	50.1	49.8	49.6	49.4	49.1	48.9	48.6	48.4	48.1
47.8	47.6	47.3	47.1	46.8	46.5	46.3	46.0	45.8	45.5
45.3	45.0	44.7	44.5	44.2	43.9	43.6	43.4	43.1	42.8
42.5	42.3	42.0	41.7	41.4	41.2	40.9	40.6	40.4	40.1
39.8	39.5	39.2	38.9	38.7	38.4	38.1	37.8	37.5	37.3
37.0	36.7	36.4	36.2	35.9	35.6	35.3	35.1	34.8	34.5
34.2	34.0	33.7	33.4	33.1	32.8	32.5	32.3	32.0	31.7
31.4	31.1	30.8	30.4	30.1	29.8	29.4	29.1	28.7	28.4
28.0	27.6	27.2	26.8	26.4	26.0	25.6	25.1	24.7	24.3
23.8	23.3	22.9	22.4	22.0	21.5	21.0	20.5	20.0	19.4
18.9	18.4	17.8	17.3	16.7	16.2	15.6	15.0	14.4	13.8
13.2	12.6	11.9	11.3	10.7	10.0	9.4	8.7	8.1	7.4
6.7	6.0	5.3	4.6	3.9	3.2	2.5	1.8	1.1	0.4
-0.3	-1.0	-1.7	-2.4	-3.1	-3.8	-4.5	-5.2	-5.9	-6.6
-7.3	-8.1	-8.8	-9.5	-10.2	-10.9	-11.6	-12.3	-13.0	-13.7
-14.4	-15.1	-15.8	-16.5	-17.2	-17.9	-18.6	-19.3	-19.9	-20.6
-21.3	-22.0	-22.6	-23.3	-23.9	-24.6	-25.2	-25.9	-26.5	-27.1
-27.7	-28.4	-29.0	-29.5	-30.1	-30.7	-31.3	-31.9	-32.4	-33.0
-33.5	-34.1	-34.6	-35.2	-35.7	-36.2	-36.7	-37.2	-37.7	-38.2
-38.6	-39.1	-39.6	-40.0	-40.5	-41.0	-41.4	-41.8	-42.3	-42.7
-43.1	-43.4	-43.6	-43.7	-43.9	-44.0	-44.1	-44.3	-44.4	-44.5
-44.6	-44.6	-44.6	-44.6	-44.5	-44.4AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA				

TEST: 183 PAYLOAD SLED DISP IN INCHESAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

0.0	0.6	1.2	1.9	2.5	3.1	3.7	4.3	4.9	5.6
6.2	6.8	7.4	8.0	8.6	9.1	9.7	10.3	10.9	11.5
12.1	12.6	13.2	13.8	14.3	14.9	15.4	16.0	16.5	17.1
17.6	18.2	18.7	19.3	19.8	20.3	20.9	21.4	21.9	22.4
22.9	23.4	23.9	24.4	24.9	25.4	25.9	26.4	26.9	27.4
27.9	28.3	28.8	29.3	29.7	30.2	30.7	31.1	31.6	32.0
32.5	32.9	33.3	33.8	34.2	34.6	35.1	35.5	35.9	36.3
36.7	37.2	37.5	38.0	38.3	38.8	39.1	39.5	39.9	40.3
40.7	41.0	41.4	41.8	42.2	42.5	42.9	43.2	43.6	43.9
44.3	44.6	44.9	45.2	45.5	45.9	46.2	46.5	46.8	47.1
47.4	47.6	47.9	48.2	48.5	48.7	49.0	49.2	49.5	49.7
49.9	50.2	50.4	50.6	50.8	51.0	51.2	51.4	51.5	51.7
51.9	52.0	52.2	52.3	52.4	52.6	52.7	52.8	52.9	53.0
53.1	53.2	53.2	53.3	53.3	53.4	53.4	53.4	53.5	53.5
53.5	53.5	53.4	53.4	53.4	53.3	53.3	53.2	53.2	53.1
53.0	52.9	52.8	52.7	52.6	52.5	52.3	52.2	52.0	51.9
51.7	51.5	51.3	51.1	50.9	50.7	50.5	50.3	50.0	49.8
49.5	49.3	49.0	48.7	48.5	48.2	47.9	47.6	47.3	46.9
46.6	46.3	45.9	45.6	45.2	44.8	44.5	44.1	43.7	43.3
42.9	42.5	42.1	41.7	41.3	40.8	40.4	39.9	39.5	39.0
38.6	38.1	37.6	37.2	36.7	36.2	35.7	35.2	34.7	34.2
33.7	33.2	32.6	32.1	31.6	31.0	30.5	30.0	29.5	28.9
28.4	27.9	27.3	26.8	26.3	25.7AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA				

TEST: 183 CARRIER SLED VEL IN FPSAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

52.6	52.4	52.1	51.9	51.7	51.4	51.2	50.9	50.7	50.5
50.2	50.0	49.8	49.5	49.3	49.0	48.8	48.5	48.3	48.0
47.8	47.5	47.3	47.0	46.8	46.5	46.3	46.0	45.8	45.5
45.3	45.0	44.7	44.5	44.2	43.9	43.6	43.4	43.1	42.8
42.5	42.3	42.0	41.7	41.5	41.2	40.9	40.6	40.4	40.1
39.8	39.5	39.2	39.0	38.7	38.4	38.1	37.9	37.6	37.3
37.0	36.8	36.5	36.2	36.0	35.7	35.4	35.1	34.8	34.6
34.3	34.0	33.8	33.5	33.2	32.9	32.6	32.4	32.1	31.8
31.5	31.2	30.9	30.7	30.4	30.1	29.8	29.6	29.3	29.0
28.8	28.5	28.2	28.0	27.7	27.4	27.2	26.9	26.6	26.4
26.1	25.9	25.6	25.3	25.1	24.8	24.6	24.3	24.0	23.8
23.5	23.3	23.0	22.7	22.5	22.2	22.0	21.7	21.5	21.2
20.9	20.7	20.4	20.2	19.9	19.7	19.4	19.2	18.9	18.7
18.4	18.2	17.9	17.7	17.4	17.2	16.9	16.7	16.4	16.2
15.9	15.7	15.4	15.2	15.0	14.7	14.5	14.2	14.0	13.8
13.5	13.3	13.0	12.8	12.6	12.3	12.1	11.8	11.6	11.3
11.1	10.8	10.6	10.3	10.1	9.8	9.6	9.3	9.1	8.8
8.6	8.3	8.0	7.8	7.5	7.3	7.0	6.7	6.5	6.2
5.9	5.7	5.4	5.1	4.8	4.6	4.3	4.0	3.7	3.5
3.2	2.9	2.6	2.3	2.0	1.8	1.5	1.2	0.9	0.6
0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA				

TEST: 183 CARRIER SLED DISP IN INCHESAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

0.0	0.6	1.2	1.9	2.5	3.1	3.7	4.3	4.9	5.6
6.2	6.8	7.4	8.0	8.6	9.1	9.7	10.3	10.9	11.5
12.1	12.6	13.2	13.8	14.3	14.9	15.4	16.0	16.5	17.1
17.6	13.2	18.7	19.3	19.8	20.3	20.8	21.4	21.9	22.4
22.9	23.4	23.9	24.4	24.9	25.4	25.9	26.4	26.9	27.4
27.9	28.3	28.8	29.3	29.7	30.2	30.6	31.1	31.6	32.0
32.5	32.9	33.3	33.8	34.2	34.6	35.1	35.5	35.9	36.3
36.7	37.2	37.6	38.0	38.4	38.8	39.2	39.5	39.9	40.3
40.7	41.1	41.4	41.8	42.2	42.5	42.9	43.3	43.6	44.0
44.3	44.7	45.0	45.3	45.7	46.0	46.3	46.6	47.0	47.3
47.6	47.9	48.2	48.5	48.8	49.1	49.4	49.7	50.0	50.3
50.6	50.9	51.1	51.4	51.7	52.0	52.2	52.5	52.7	53.0
53.2	53.5	53.7	54.0	54.2	54.5	54.7	54.9	55.2	55.4
55.6	55.8	56.0	56.2	56.5	56.7	56.9	57.1	57.3	57.5
57.7	57.9	58.0	58.2	58.4	58.6	58.8	58.9	59.1	59.3
59.4	59.6	59.8	59.9	60.1	60.2	60.3	60.5	60.6	60.8
60.9	61.0	61.2	61.3	61.4	61.5	61.7	61.8	61.9	62.0
62.1	62.2	62.3	62.4	62.5	62.6	62.7	62.7	62.8	62.9
63.0	63.0	63.1	63.2	63.2	63.3	63.3	63.4	63.4	63.5
63.5	63.5	63.6	63.6	63.6	63.7	63.7	63.7	63.7	63.7

TEST: 183 BASE FORCE IN LBSAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

3417.0	3387.4	3328.4	3269.3	3180.7	3284.1	3313.6	3476.1	3535.1	3594.2
3638.5	3461.3	3328.4	3225.0	3254.5	3284.1	3313.6	3417.0	3490.8	3520.4
3549.9	3594.2	3668.0	3727.1	3638.5	3638.5	3623.7	3594.2	3609.0	3594.2
3609.0	3623.7	3727.1	3727.1	3756.6	3800.9	3830.5	3860.0	3889.6	3963.4
3963.4	4022.5	3948.6	3889.6	3800.9	3741.9	3682.8	3697.6	3756.6	3845.3
4081.5	4037.2	4081.5	4096.3	4022.5	3992.9	3978.2	3919.1	3845.3	3874.8
3815.7	3919.1	3874.8	3874.8	3889.6	3874.8	3933.9	3860.0	3889.6	3904.3
3919.1	3948.6	3933.9	3978.2	3992.9	4037.2	4022.5	4022.5	4155.4	4081.5
4140.6	4184.9	4273.5	4332.6	4436.0	4421.2	4554.1	4627.9	4687.0	4790.4
4893.8	5011.9	5085.8	5174.4	5263.0	5381.1	5454.9	5528.8	5617.4	5735.5
5824.1	5912.8	6060.4	6134.3	6326.3	6341.0	6414.9	6503.5	6562.5	6665.9
6754.5	6798.8	6887.4	7005.6	7138.5	7271.4	7374.8	7478.1	7552.0	7640.6
7714.4	7729.2	7906.4	7906.4	7965.5	8098.4	8157.5	8246.1	8290.4	8349.4
8423.3	8526.7	8571.0	8600.5	8689.1	8615.3	8748.2	8762.9	8807.3	8851.5
8866.3	8866.3	9014.0	9058.3	9058.3	9087.8	9117.4	9161.7	9028.8	9058.3
9087.8	9102.6	9102.6	9028.8	9073.1	9028.8	9073.1	9087.8	9117.4	9058.3
9043.5	9087.8	9043.5	9014.0	9028.8	9043.5	9014.0	8999.2	8969.7	8954.9
8895.8	8851.5	8822.0	8851.5	8822.0	8822.0	8777.7	8718.6	8674.3	8615.3
8571.0	8526.7	8497.1	8452.8	8334.7	8305.1	8216.5	8142.7	8083.6	8054.1
7995.0	7817.8	7699.7	7625.8	7522.4	7433.8	7330.5	7197.5	7153.3	7079.4
6961.3	6828.4	6621.6	6503.5	6355.8	6311.5	6237.6	6193.3	6134.3	5912.8
5203.9	4096.3	2959.2	2294.6	1940.2	1984.5	2146.9	2279.9	2073.1	1836.8
1467.6	1201.8	1009.8	906.5	803.1	773.5AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA				
63.7	63.7	63.7	63.7	63.7	63.7	63.7	63.7	63.7	63.7
63.7	63.7	63.7	63.7	63.7	63.7	63.7	63.7	63.7	63.7
63.7	63.7	63.7	63.7	63.7	63.7AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA				

TEST: 183 CATAPULT EXTENSION VEL IN FPSAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.5	0.6	0.7
0.8	0.9	1.0	1.1	1.3	1.4	1.6	1.8	1.9	2.1
2.3	2.5	2.7	2.9	3.1	3.3	3.6	3.8	4.1	4.3
4.6	4.9	5.2	5.4	5.8	6.1	6.4	6.7	7.0	7.4
7.7	8.1	8.5	8.9	9.2	9.6	10.0	10.4	10.8	11.3
11.7	12.1	12.6	13.0	13.5	13.9	14.4	14.9	15.3	15.8
16.3	16.7	17.2	17.6	18.1	18.5	19.0	19.5	19.9	20.4
20.9	21.3	21.8	22.3	22.7	23.2	23.6	24.1	24.6	25.0
25.5	25.9	26.4	26.8	27.3	27.7	28.1	28.6	29.0	29.4
29.8	30.3	30.7	31.1	31.5	31.8	32.2	32.6	33.0	33.3
33.7	34.0	34.4	34.7	35.0	35.3	35.6	35.9	36.2	36.4
36.7	37.0	37.2	37.5	37.7	37.9	38.2	38.4	38.5	38.7
39.0	39.2	39.6	40.0	40.5	40.9	41.4	41.8	42.3	42.7
43.0	43.4	43.6	43.7	43.9	44.0	44.1	44.3	44.4	44.5
44.6	44.6	44.6	44.6	44.5	44.4AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA				

TEST: 183 CARRIER SLED ACCEL IN GSAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

7.1	7.1	7.2	7.3	7.5	7.5	7.5	7.4	7.4	7.3
7.3	7.3	7.4	7.5	7.6	7.6	7.6	7.7	7.7	7.7
7.7	7.8	7.8	7.8	7.8	7.8	7.8	7.9	7.9	8.1
8.1	8.2	8.3	8.4	8.5	8.6	8.6	8.6	8.5	8.5
8.5	8.5	8.5	8.4	8.4	8.5	8.5	8.6	8.6	8.6
8.7	8.6	8.6	8.6	8.6	8.6	8.5	8.4	8.4	8.4
8.4	8.5	8.5	8.5	8.5	8.5	8.5	8.6	8.6	8.6
8.6	8.6	8.6	8.6	8.6	8.6	8.7	8.7	8.8	8.8
8.8	8.8	8.8	8.7	8.6	8.5	8.4	8.4	8.3	8.3
8.3	8.3	8.2	8.3	8.3	8.3	8.2	8.2	8.2	8.1
8.1	8.1	8.0	8.0	7.9	8.0	8.0	8.0	8.0	8.0
8.1	8.1	8.1	8.1	8.1	8.1	8.0	7.9	7.9	7.9
7.9	7.9	7.8	7.9	7.9	7.9	7.9	7.8	7.8	7.8
7.7	7.7	7.7	7.7	7.7	7.6	7.6	7.6	7.6	7.6
7.7	7.6	7.6	7.5	7.5	7.5	7.5	7.5	7.4	7.5
7.5	7.5	7.5	7.6	7.6	7.6	7.6	7.7	7.7	7.7
7.6	7.7	7.7	7.7	7.8	7.8	7.8	7.9	7.9	7.9
7.9	8.0	8.0	8.0	8.1	8.1	8.1	8.2	8.2	8.3
8.3	8.4	8.4	8.4	8.5	8.6	8.6	8.6	8.7	8.7
8.8	8.8	8.9	9.0	9.0	9.1	9.1	9.1	9.1	8.8
7.5	4.8	1.6	-0.6	-1.5	-1.2	-0.5	0.2	0.6	0.6
0.5	0.2	-0.1	-0.3	-0.2	-0.1	-0.1	0.1	0.1	0.0
-0.2	-0.3	-0.2	0.0	0.0	0.0AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA				

TEST: 183 PAYLOAD SLED ACCEL IN GSAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

7.4	7.6	7.5	7.3	7.3	7.2	7.1	6.9	6.6	6.6
6.8	7.2	7.4	7.6	7.7	7.8	7.7	7.7	7.8	7.9
8.1	8.1	8.1	8.1	8.0	8.0	8.0	7.9	7.8	7.8
8.0	8.3	8.4	8.6	8.7	8.6	8.5	8.4	8.3	8.5
8.7	8.8	8.8	8.6	8.4	8.2	8.1	8.0	8.2	8.6
9.1	9.3	9.2	8.9	8.8	8.8	8.7	8.5	8.4	8.4
8.5	8.6	8.6	8.6	8.6	8.6	8.5	8.5	8.4	8.6
8.6	8.6	8.6	8.6	8.8	8.9	9.1	9.1	9.1	9.2
9.4	9.6	9.7	9.9	10.4	10.5	10.9	11.1	11.2	11.4
11.8	12.1	12.4	12.5	12.7	13.0	13.3	13.4	13.6	13.8
14.0	14.2	14.3	14.5	14.9	15.2	15.5	15.7	15.9	16.2
16.5	16.7	16.9	17.1	17.5	17.8	18.0	18.3	18.4	18.8
19.1	19.4	19.6	19.6	19.8	20.1	20.4	20.6	20.8	21.0
21.4	21.5	21.5	21.6	21.8	21.9	22.0	22.1	22.2	22.3
22.3	22.0	21.6	21.5	21.5	21.7	21.8	21.8	21.9	21.9
22.1	22.1	22.0	21.9	21.9	21.9	21.8	21.8	21.7	21.7
21.8	21.7	21.6	21.6	21.5	21.5	21.3	21.1	21.0	21.0
21.1	20.9	20.7	20.4	20.2	20.0	19.9	19.7	19.5	19.4
19.2	19.0	18.6	18.1	17.8	17.7	17.8	17.6	17.4	17.2
17.1	17.0	16.7	16.4	16.1	15.9	15.7	15.3	14.9	14.7
14.7	14.7	14.6	14.4	14.1	14.0	13.8	13.6	13.1	12.6
10.7	8.2	5.6	4.2	3.7	4.0	4.2	3.9	3.6	3.0
2.0	0.6	-0.6	-1.7	-2.8	-3.2AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA				

TEST: 183 CATAPULT EXTENSION IN INCHESAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6
0.6	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.2	1.3
1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.3	2.4
2.5	2.7	2.8	3.0	3.1	3.3	3.5	3.6	3.8	4.0
4.2	4.4	4.6	4.8	5.0	5.3	5.5	5.7	5.9	6.2
6.4	6.7	6.9	7.2	7.5	7.8	8.0	8.3	8.6	8.9
9.2	9.5	9.8	10.2	10.5	10.8	11.1	11.5	11.8	12.2
12.5	12.9	13.3	13.6	14.0	14.4	14.8	15.2	15.6	15.9
16.4	16.8	17.2	17.6	18.0	18.4	18.9	19.3	19.7	20.1
20.6	21.0	21.5	21.9	22.4	22.8	23.3	23.8	24.2	24.7
25.1	25.6	26.1	26.6	27.0	27.5	28.0	28.5	29.0	29.5
30.0	30.6	31.1	31.6	32.1	32.7	33.2	33.7	34.3	34.8
35.3	35.9	36.4	36.9	37.5	38.0AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA				

APPENDIX C

Program Listing of "DATA/MOD"

```
      $RESET FREE
      $SET OWN
      FILE 6(TITLE="DDT183",KIND=DISK,MAXRECSIZE=14,BLOCKSIZE=420)
      FILE 7(TITLE="GP183",KIND=DISK,MAXRECSIZE=14,BLOCKSIZE=420)
      FILE 8(TITLE="DDATA183",KIND=DISK,MAXRECSIZE=14,BLOCKSIZE=420,
     .PROTECTION=SAVE)
      DIMENSION Y(250),X(250),Z(250)
C      FILE 6 IS DISPLACEMENT DATA FROM ACTUAL TEST (TEST 183)
      N=226
      READ(6,100)(X(J),J=1,N)
C     READ(7,100)(Y(J),J=1,N)
  100 FORMAT(10F8.2)
C     WRITE OUT THE RESULTS IN THE NEW FORMAT.  THE NEW DATA TABLE
C     WILL ALSO BE SHIFTED IN TIME IF REQUIRED.  START DATA STRING AT
C     16TH ELEMENT.  MAKE THIS NEW FIRST TERM ZERO AND ELIMINATE EVERY
C     SECOND TERM.
      X(16) = 0.0
      WRITE(8,101)(X(J),J=16,N,2)
 101  FORMAT(8F10.4)
      STOP
    END
```

APPENDIX D

Program Listing of "GRAPH"

```
$INCLUDE "=3140/CALCOMP/FORTRAN} INFILE."
$RESET FREE
FILE  5=G160,UNIT=DISK,RECORD=14,BLOCKING=30
FILE  5=SDAT#160,UNIT=DISK,RECORD=14,BLOCKING=30
FILE  7=TIME,UNIT=DISK,RECORD=1,BLOCKING=30
FILE  8(TITLE="OUT",KIND=REMOTE,MAXRECSIZE=14,BLOCKSIZE=420,
     .PROTECTION=SAVE)
      DIMENSION X(2,200),Y(2,200)
      N=76
      K=2
      READ(5,105)((Y(I,J),J=1,N),I=1,1)
      READ(6,105)((Y(I,J),J=1,N),I=2,2)
C     DO 15   I = 1,K
C     READ(5,105)(Y(I,J),J=1,N)
C     READ(7,105)(X(I,J),J=1,N)
C15   CONTINUE
      WRITE(6,105)(((I,J),J=1,N) I=1,K)
  105 FORMAT(FF10.4)
  106 FORMAT(10F8.2)
      I = 1
      L = 0
      DO 10 J=1,N
      X(I,J)=L
      L = L + 2
   10 CONTINUE
      I=2
      L=0
      DO 20   J = 1,N
      X(I,J)= L
      L = L + 2
   20 CONTINUE
      WRITE(6,105)((((I,J),J=1,N),I=1,2)
      WRITE(6,30) N,K
   30 FORMAT(10X,"N=",F8.3,2X,"K=",I5)
      CALL RPLOT(N,K,X,Y)
   50 FORMAT(20I4)
      END
      SUBROUTINE RPLOT(N,K,X,Y)
C   PROVIDES A TWO DIMENSIONAL MULTILINE PLOT.  N IS THE NUMBER OF
C   POINTS TO BE PLOTTED. K IS THE NUMBER OF SETS OF DATA (SAME PLOT).
C   AND X,Y ARE TWO DIMENSIONAL ARRAYS (K,N).  TITLES, ETC. ARE PROVIDED.
C   PLOT IS 8X8 IN.  TITLES/LABELS ARE INTENDED TO BE CHANGED FOR
C   INDIVIDUAL USE.  ACCEPTS THREE SETS OF DATA OF 150 POINTS EACH, BUT
C   THESE LIMITS ARE CHANGEABLE.  TITLES "ABSCISSA, ORDINATE,FIRST LINE
C   SAMPLE PLOT," ETC. SHOULD BE CHANGED TO REFLECT ACTUAL TITLES.  BLANK
C   SPACES IN THE HOLLERITH FIELD SHOULD NOT BE UNINTENTIONALLY REMOVED.
      INTEGER B
      REAL M
      DIMENSION X(2,200),Y(2,200),XA(200),YA(200),Z(2),Q(2)
C   SET PLOT DIMENSIONS: R IS THE LENGTH OF X-AXIS IN INCHES, U LENGTH
C   OF Y-AXIS.  SET SET POSITION OF KEY RELATIVE TO PLOT.
C   NEGATIVE SIGN REQUIRED IN VALUE OF R ; DEFAULT SIZE IS 8X8 IN
      R=-8.
```

```
      AR=ABS(R)
      U=5.
      S=ABS(L)/2
      T=AR+1
      V=AR+7
      Q(1)=0
      Q(2)=1400
      Z(1)=0
      Z(2)=1 75
C   SIZE AXES FOR ALL DATA
      CALL SCALE(Z,2,AR,M,D)
      XM   =M
      XD   =25
      CALL SCALE(Q,2,U,M,D)
      YM   =M
      YD   =2.5
      IA=-117
C   PRINT AXES, TITLES
      CALL AXIS(0,0,24HTIME (MILLISECONDS)      ,-24, R,0,XM,XD)
      CALL SYMBOL(1,-1,.2,24HG COMPARISON: TEST 160   ,0,24)
      CALL AXIS(0,0,24HCATAPULT ACCELERATION    ,24,U,90,YM,YD)
      WRITE(6,50) N,C
   50 FORMAT(10X,"N=",F8.3,2X,"C=",I5)
      DO 20 J=1,K
      DO 30 I=1,N
      XA(I)=X(J,I)
   30 YA(I)=Y(J,I)
C   SCALE EACH SET OF DATA TO PROPER SIZE FOR PLOT
      CALL SCALES(XA,N,XM,XD)
      CALL SCALES(YA,N,YM,YD)
C   SYMBOL PLOTTED EVERY A DATA POINTS  CHANGE AS DESIRED
C   NO SYMBOL FOR SINGLE SET OF DATA
      A=50
       IF(K.EQ.1)A=0
C   EVERY POINT WILL BE PLOTTED IF E=1 EVERY ITH POINT IF B=I
      B=1
C   PLOT THE POINTS
      CALL LYNE(XA,YA,N,B,A,IA)
      IA=IA-1
      CALL PLOT(0,0,5)
   20 CONTINUE
       IF(K.EQ.1) GO TO 40
      DO 40 I=1,K
C   IDENTIFIES MULTIPLE LINES
      CALL SYMBOL(T,S,.1,16H                ,0,16)
      C=S-.5*FLOAT(I)
```

```
      IF (I.EQ.1) GO TO 100
      IF (I.EQ.2) GO TO 200
      IF (I.EQ.3) GO TO 300
      IF (I.EQ.4) GO TO 301
      IF (I.EQ.5) GO TO 302
      IF (I.EQ.6) GO TO 303
      IF (I.EQ.7) GO TO 304
      IF (I.EQ.8) GO TO 305
      IF (I.EQ.9) GO TO 306
      IF (I.EQ.10) GO TO 307
      IF (I.EQ.11) GO TO 308
      IF (I.EQ.12) GO TO 309
  100 CALL SYMBOL(T ,C,.10,21H  COMPUTER G RESULTS ,0,21)
       GO TO 400
  200 CALL SYMBOL(T ,C,.10,21H  TEST DATA G VALUES ,0,21)
       GO TO 400
  300 CALL SYMBOL(T ,C,.10,16H    TEST 183 ,0,16)
       GO TO 400
  301 CALL SYMBOL(T ,C,.10,16H    TEST 180 ,0,16)
       GO TO 400
  302 CALL SYMBOL(T ,C,.10,16H    TEST 181 ,0,16)
       GO TO 400
  303 CALL SYMBOL(T ,C,.10,16H    TEST 183 ,0,16)
       GO TO 400
  304 CALL SYMBOL(T ,C,.10,16H    TEST 184 ,0,16)
       GO TO 400
  305 CALL SYMBOL(T ,C,.10,16H    TEST 185 ,0,16)
       GO TO 400
  306 CALL SYMBOL(T ,C,.10,16H    TEST 186 ,0,16)
       GO TO 400
  307 CALL SYMBOL(T ,C,.10,16H    TEST 196 ,0,16)
       GO TO 400
  308 CALL SYMBOL(T ,C,.10,16H    TEST 197 ,0,16)
       GO TO 400
  309 CALL SYMBOL(T ,C,.10,16H    TEST 198 ,0,16)
  400 CONTINUE
   40 CONTINUE
      CALL PLOT(V,0,999)
      RETURN
      END
```

APPENDIX E

Program Listing of (DYNMO)

Catapult Model with Data Set (NEWSET)

```
$RESET FREE
$SET OWN
C$SET LIST
FILE  5(TITLE="NEWSET",KIND=DISK,FILETYPE=7)
FILE  6(KIND=PRINTER,MAXRECSIZE=60)
FILE  7(TITLE="PRESS",KIND=DISK,MAXRECSIZE=14,BLOCKSIZE=420,
     .PROTECTION=SAVE)
FILE  8(TITLE="GACCZ",KIND=DISK,MAXRECSIZE=14,BLOCKSIZE=420,
     .PROTECTION=SAVE)
FILE  9(TITLE="DISP",KIND=DISK,MAXRECSIZE=14,BLOCKSIZE=420,
     .PROTECTION=SAVE)
FILE  10(TITLE="WB",KIND=DISK,MAXRECSIZE=14,BLOCKSIZE=420,
     .PROTECTION=SAVE)
FILE  11(TITLE="W",KIND=DISK,MAXRECSIZE=14,BLOCKSIZE=420,
     .PROTECTION=SAVE)
C     PROGRAM CATAPULT

C
      DIMENSION OUT(100),OUTMAX(100),OUTMIN(100),WDW(250),CA(4),
     .WORK(18),GLF(220),GACCZ(200),DISP(200)
      COMMON  /GDATA/ GDT(3,220)
      COMMON /OUTDAT/ TIME,CASE,GEEZ,VELC,STROKE,HT,VOL,DRI,BRP,BW,BA,
     .              W,TEMP,PRESS,EK,EP,FE,HE,CADF,THA,FRF,ORK,RPLRT,TLF,
     .                 RFE,BB,WRKDOT,WRK,HP
      COMMON /CATDAT/ PL(250),WBG(250),  WG(250), CTCC(250), CT1(250),
     .                 RK1(250),PR1(250),NPTS,PSI(250)
       COMMON /TESTDT/ P(30,3,3),TIMEP(30,3,3),DAT(25,3)
      COMMON /INTG/ SUM(10),PSUM(10),RATE(10),SAVE(10)
C
      EQUIVALENCE (RATE(1),ACCB   ),(SUM(1),VELB   ),
     .            (RATE(2),VELBB  ),(SUM(2),DISTB  ),
     .            (RATE(3),ACCZ   ),(SUM(3),VELZ   ),
     .            (RATE(4),VELZZ  ),(SUM(4),DISTZ  ),
     .            (RATE(5),PBR    ),(SUM(5),WB     ),
     .            (RATE(6),EFDOT  ),(SUM(6),  EF   ),
     .            (RATE(7),ELDOT  ),(SUM(7),  EL   ),
     .            (RATE(8),WKDOT  ),(SUM(8), WK    )
C                 (RATE(9),EPDOT  ),(SUM(9),  EP   ),
C                 (RATE(10),EKDOT ),(SUM(10),  EK  )
      EQUIVALENCE (OUT(1),TIME)
C
      REAL K1,K2,K3,K4,K41
       NAMELIST /NEWSET/ DT,CO,TEST,C,PA,EJW,STROFF,VO,B,PXP,RM,K1,
     .                  K3,RHOP,RHO,OMEGA,THETA,ZLF,NPRT,TFLAME,CV,PLOCK
     .                  CTMP,MODE,IDIAG,CGD,RLRD,K2,DPLMT,NOUT,IFPLT,K4,
     .                  IFPRT,MODEL,TIGN,RK,ICOND,ISTOPQ
C
C*******************************************************************
C***
C***   ACCB     THE DEFLECTION ACCELERATION OR "SLUMP" ACCELERATION
C***            OF THE MAN IN THE DRI EQUATION (FT/SEC**2)
C***   ACCZ     THE DRIVING ACCELERATION THAT ACTS AS THE FORCING TERM
C***            IN THE DRI EQUATION (FT/SEC**2)
C***   ADWDWB   THE AVERAGE SLOPE (DW/DWB) OF THE PROPELLANT CONSUMPTION
C***            CURVE (SLUGS/IN)
C***
C***   B        THE BURN RATE EXPONENT (IN/SEC/PSI)
```

```
C***  BA      BURNING AREA (IN**2)                                          00004200
C***  BB      AN ALTERNATE VARIABLE NAME FOR B                              00004300
C***  BBB     A LOCATION IN WHICH TO SAVE AN ORIGINAL B DURING ANY CASE     00004400
C***  BRP     PRINTOUT VARIABLE NAME FOR BURN RATE                          00004500
C***  BW      PRINTOUT VARIABLE NAME FOR PROPELLANT CONSUMED                00004600
C***  C       TOTAL AVAILABLE PROPELLANT (SLUGS)                            00004700
C***  CA      UNDEFINED                                                     00004800
C***  CADF    NET FORCE EXECUTED BY THE CATAPULT (LBS)                      00004810
C***  CASE    CASE NUMBER IDENTIFIER                                        00004820
C***  CGD     PERPENDICULAR DISTANCE BETWEENTHE CG OF THE PROPELLED         00004830
C***          MASS AND THE AXIS OF THE GUIDE RAILS (FT)                     00004840
C***  CLF     COMPUTED LOAD FACTOR PARALLEL TO RAIL AXIS (NON DIM)          00004850
C***  CTCC    AN ALTERNATE ARRAY NAME FOR TIME                              00004860
C***  CTEMP   TEMPERATURE CONDITION OF THE PROPELLANT AT THE BEGINNING      00004870
C***          OF THE CASE (DEGREE F)                                        00004880
C***  CTH     COSINE OF THE ANGLE BETWEEN THE G FIELD AND THE RAILS(ND)     00004890
C***  CTMP    INPUT VERSION OF CTEMP  (DEGREE F)                            00004900
C***  CT1     AN ALTERMATE ARRAY NAME FOR PROPELLANT CONSUMED(W)(SLUGS)     00004910
C***  CV      SPECIFIC HEAT OF THE PROPELLANT (FT-LBS/SLUGS K)              00004920
C***  CO      IGNITER PROPELLANT (SLUGS)                                    00004930
C***  DAT     AN ALTERNATE ARRAY NAME FOR MANY VARIABLES                    00004940
C***  DGR     CONSTANT TO CONVERT DEGREES TO RADIANS                        00004950
C***  DISTB   SLUMP DISPLACEMENT OF MAN DURING LOADING THE DISPLACEMENT     00004960
C***          TERM IN THE DR. EQUATION (FT)                                 00004970
C***  DISTZ   THE INTEGRATED PAYLOAD DISPLACEMENT ALONG THE RAILS (FT)      00004980
C***                (CURRENT INTERATION)                                    00004990
C***  DPLMT   CONVERGENCE ERROR LIMIT ON PRESSURE WHEN PRESSURE COM-        00005000
C***          PARISONS ARE BEING MADE DURING A PRESSURE COMPARISON RUN.     00005010
C***           (PSI)                                                        00005020
C***  DRI     DRI (ND)                                                      00005030
C***  DT      DELTA TIME STEP FOR INTEGRATION                               00005040
C***  EF      O RING FRICTIONAL ENERGY DISSIPATED (FT-LBS)                  00005050
C***  EFDOT   O RING FRICTIONAL ENERGY RATE (FT-LBS/SEC)                    00005060
C***  EJM     PAYLOAD MASS (SLUGS)                                          00005070
C***  EJW     PAYLOAD WEIGHT (LBS)                                          00005080
C***  EK      KINETIC ENERGY OF PAYLOAD (FT-LBS)                            00005090
C***  EL      HEAT ENERGY LOST OVERBOARD (FT-LBS)                           00005100
C***  ELDOT   HEAT ENERGY LOSS RATE  (FT-LBS/SEC)                           00005110
C***  EP      POTENTIAL ENERGY  (FT-LBS)                                    00005120
C***  EPDOT   POTENTIAL ENERGY RATE (FT-LBS/SEC)                            00005130
C***  FE      PRINTOUT VARIABLE NAME FOR EF                                 00005140
C***  FILDOT  VOLUME RATE THAT CURRENT PROPELLANT CONSUMPTION RATE          00005150
C***          COULD SUPPORT AT THE CURRENT PRESSURE (IN**3/SEC)             00005160
C***  FRF     SLIDER BLOCK FRICTION LOAD (LBS)                              00005170
C***  FRLR    ROLLER TO RAIL LOAD (LBS)                                     00005180
C***  G       32.174 FT/SEC**2                                              00005190
C***  GEEZ    ACCZ/32.174                                                   00005200
C***  HE      PRINTOUT VARIABLE NAME FOR EL                                 00005210
C***  HP      HORSEPOWER OUTPUT OF CATAPULT                                 00005220
C***  HT      HEIGHT OR DISTANCE TRAVELLED THROUGH THE G FIELD              00005230
C***  I       INTEGER INDEX USED SEVERAL PLACES                             00005240
C***  ICOND   INTEGER FLAG INDICATING TEMPERATURE CONDITION.                00005250
C***                1=COLD       2=ROOM       3=HOT                         00005260
C***  IDIAG   INTEGER FLAG THAT DUMPS ALL VARIABLES FROM CADS EACH TIME     00005270
C***          THRU TO AID IN DIAGNOSIS FOR DEBUGGING PURPOSES               00005280
C***  IFIRST  FLAG INDICATING THE FIRST TIME THRU THE CODE. ONLY ONCE       00005290
C***          PER CASE                                                      00005300
C***  IFPLT   FLAG TO REQUEST PLOTTING  0=NO  PLOTTING REQUIRED             00005310
C***  INT     INTEGRATION ITERATION COUNTER: 1-4                            00005320
C***  IPRT    FLAG SELECTING OUTPUT VS NO OUTPUT                            00005330
C***  ISNUFF  FLAG INDICATING THAT THE PROPELLANT HAS APPARENTLY SNUFF-     00005340
C***          OUT. (CODE MAY NOT BE CORRECT)                                00005350
C***  ISTOPQ  PROGRAM STOP QUE   ISTOPQ=0 CONTIN    ISTOPQ=1 END            00005351
C***  K1      PROPORTIONALITY CONSTANT BETWEEN CATAPULT PRESSURE AND        00005360
```

```
C***          INTERNAL FRICTION FORCE (LBS/PSI)                        00005370
C***  K2      PROPORTIONALITY CONSTANT BETWEEN FORCE ON SLIDER BLOCK   00005380
C***          AND FRICTION IN RAILS. (ND)                              00005390
C***  K3      PROPORTIONALITY CONSTANT BETWEEN: (SPACE AVERAGE GAS     00005400
C***          TEMPERATURE (TEMP)-CATAPULT CONDITION TEMPERATURE(CTEMP) 00005410
C***          AS WELL AS THERMAL BOUNDARY AREA (FT LBS/IN**2-K)        00005420
C***  K4      NO LONGER USED                                           00005430
C***  K41     NO LONGER USED                                           00005440
C***  MODE    INTEGER FLAG INDICATING WHETHER OR NOT THIS CASE IS      00005450
C***          DEVELOPING A PROPELLANT CONSUMPTION CURVE BY EVALUATING  00005460
C***          A PRESSURE CURVE, OR IT'S RUNNING FROM A PREVIOUSLY      00005470
C***          DEVELOPED CONSUMPTION CURVE. O-RUNNING  NON O-DEVELOPING 00005480
C***  MODEL   INTEGER SERVING AS A SUBSCRIPT TO THE DAT ARRAY TO SELECT 00005490
C***          GIVEN DATA FROM THE TESTDAT BLOCK.                       00005500
C***  NCASE   AN INTEGER CASE COUNTER FOR MULTICASE RUNS               00005510
C***  NOUT    NUMBER OF OUTPUT VARIABLES                               00005520
C***  NPRT    PRINT EACH NPRT-TH TIME. (PRINTING INTERVAL)             00005530
C***  NPT     NUMBER OF POINTS IN THE OUTPUT ARRAYS TO BE PLOTTED      00005540
C***  NPTS    NUMBER OF POINTS ON THE CURVE TO BE INTERPOLATED         00005550
C***  NPTW    NUMBER OF VALUES OF PROPELLANT CURVE SLOPES USED IN      00005560
C***          COMPUTATION OF AVERAGE SLOPE                             00005570
C***  NV      NUMBER OF VVARIABLES INTEGRATED                          00005580
C***  OMEGA   NATURAL FREQUENCY OF MAN USED IN DRI INJURY MODEL        00005590
C***  OMGASQ  OMEGA SQUARED                                            00005600
C***  OUT     THE OUTPUT ARRAY NAME                                    00005610
C***  OUTMAX  ARRAY NAMES FOR THE MAXIMUM AND MINIMUM VALUES OF THE    00005620
C***          OUTPUT                                                   00005630
C***  OUTMIN  SEE LINE ABOVE                                           00005640
C***  P       ARRAY NAME FOR PRESSURES IN TEST DATA/TESTDAT/           00005650
C***  PA      PISTON AREA (IN*IN)                                      00005660
C***  PBR     PROPELLANT LINEAR BURN RATE (IN/SEC)                     00005670
C***  PC      PISTON CIRCUMFERENCE  (IN)                               00005680
C***  PDC     PISTON DIAMETER (IN)                                     00005690
C***  PDISTZ  INTEGRATED DISPLACEMENT OF PAYLOAD (PREVIOUS INTEGRATION) 00005700
C***          (FT)                                                     00005710
C***  PDOT    NO LONGER USED                                           00005720
C***  PE      OUTPUT VARIABLE NAME FOR POTENTIAL ENERGY EP             00005730
C***  PIE     3.14159                                                  00005740
C***  PL      ALTERNATE ARRAY NAME FOR PROPELLANT WEB BURNED           00005750
C***  PLOCK   CATAPULT UNLOCK PRESSURE (PSI)                           00005760
C***  PP      CATAPULT PRESSURE (PREVIOUS ITERATION)  (PSI)            00005770
C***  PRESS   CATAPULT PRESSURE (CURRENT ITERATION)  (PSI)             00005780
C***  PR1     ALTERNATE ARRAY NAME FOR PBR                             00005790
C***  PSI     ALTERNATE ARRAY NAME FOR PRESS                           00005800
C***  PSUM    INTEGRATION ARRAY NAME FOR THE ALL PREVIOUSLY INTEGRATED 00005810
C***          VALUES OF THE INTEGRATED VARIABLE                        00005820
C***  PW      PROPELLANT CONSUMED (SLUGS)   PREVIOUS ITERATION....     00005830
C***  PXP     BURN RATE EXPONENT ON PRESSURE                           00005840
C***  RATE    ARRAY NAME FOR ALL INTEGRATABLES                         00005850
C***  RPLRT  REPLACEMENT RATIO        FILDOT/VOLDOT                    00005860
C***  RFE     RAIL FRICTION ENERGY   (FT-LBS)                          00005870
C***  RHO     DAMPING COEFFICIENT IN DRI INJURY MODEL  (ND)            00005880
C***  RHOP    DENSITY OF PROPELLANT  (SLUGS/IN**3)                     00005890
C***  RK      AN ARBITRARY MULTIPLIER ON THE CONVERGENCE STEP SIZE IN   00005900
C***  RK1     ALTERNATE ARRAY NAME FOR BURN RATE PRESSURE COEFFICIENT  00005910
C***  RLRD    DISTANCE BETWEEN ROLLERS/SLIDER BLOCKS (FT)              00005920
C***  RM      GAS CONSTANT (144. * FT-LBS/SLUG-K)                      00005930
C***  RMOM    MOMENT GENERATED BY ROLLER/SLIDER BLOCKS (FT-LBS)        00005940
C***  ROZMGA  2.*RHO*OMEGA                                             00005950
C***  RPLRT   ALTERNATE VARIABLE NAME FOR REPLRT                       00005960
C***  RTEMP   NO LONGER USED                                           00005970
C***  SAVE    AN ARRAY USED BY THE INTEGRATOR                          00005980
C***  STRKDT  DX/DT OF CATAPULT.  THE SAME AS VELZ.                    00005985
C***  STRPFL  FLAG NOTING THE OCCURRANCE OF CATAPULT STRIPOFF          00005990
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C***   STRIPT   TIME AT STRIPOFF  (SECONDS)
C***   STROKE   CATAPULT PISTON TRAVEL  (IN)
C***   SUM      AN ARRAY USED BY THE INTEGER
C***   TDWDWB   SUMMATION OF SLOPES OF PROPELLANT CONSUMPTION CURVE. (FOR
C***            AVERAGE SLOPE COMPUTATION)
C***   TEST      DYNAMIC TEST NO: 1(171),2(183),3(180)
C***        TEST=0 : G LEVEL IS CONSTANT
C***    ITEST    INTEGER FORM OF TEST
C***   TFLAME   ADIABATIC FLAME TEMPERATURE (K)
C***   THA      EXPOSED AREA TO CATAPULT GASES (IN**2)
C***   STROFF   LENGTH OF STROKE AT CATAPULT STRIPOFF  (IN)
C***   THETA    ANGLE OF RAILS IN G FIELD (DEG)
C***   TIG      PROPELLANT IGNITION TEMPERATURE (K)
C***   TIGN     INPUT VERSION OF TIG  (F)
C***   TIME     CURRENT TIME  (SECS)
C***   TIMEP    ARRAY NAME FOR TIME:PRESSURE TIME CURVE OF TEST DATA (S)
C***   TLF      G FIELD LOAD FACTOR COMPONENT PARALLEL TO RAILS
C***   TLO      INITIAL VOLUME/PISTON AREA  (IN)
C***   VELB     MAN DEFLECTION VELOCITY IN DRI MODEL (FT/SEC)
C***   VELBB    SAME AS VELB
C***   VELC     CATAPULT VELOCITY  (FT/SEC)   OUTPUT NAME
C***   VELZ     WORKING VERSION OF VELC
C***   VELZZ    SAME AS VELZ
C***   VOL      CURRENT CATAPULT VOLUME (IN**3)
C***   VOLDOT   RATE OF INCREASE OF VOL  (IN**3/SEC)
C***   VO
C***   W        PROPELLANT CONSUMMED  (SLUGS)
C***   WB       PROPELLANT WEB CONSUMMED  (IN)
C***   WBG      ALTERMATE ARRAY NAME FOR WB
C***   WDOT     PROPELLANT CONSUMPTION RATE  (SLUGS/SEC)
C***   WDW      NOT USED
C***   WG       ALTERNATE ARRAY NAME FOR W
C***   WK       WORK DONE BY CATAPULT   (FT-LBS)
C***   WKDOT    RATE OF DOING WORK BY CATAPULT  (FT-LBS/SEC)
C***   ZLF      G FIELD LOAD FACTOR

C**************************************************************


      NCASE = 0
      IPRT  = 0
    1 READ (5,NEWSET)
      IF(ISTOPQ.EQ.1)   GO TO 6
C
C  INITIALIZE..........
C
      IF (MODE.EQ.0)
      NCASE = NCASE + 1
      TIME = 0.0
       NV = 8
      INT = 0
      NPT = 1
      DO 3 I=1,40
    3 SUM(I) = 0.0
      DGR = 0.017453292
      CASE = NCASE
      CTEMP = (CTMP-32.)*.55555 + 273.0
      TIG = (TIGN-32.)*.55555+273.
      PP = 0.0
      VOL = VO
      DRI = 0.0
      WB = 0.000001
      W = 0.000001
      RA = 0.0
```

```
      PW = 0.0
      PRESS = 14.7
      G = 32.174
      RO2MGA = RHO*2.0*OMEGA
      OMGASQ = OMEGA*OMEGA
      DO 20 I=1,NOUT
      OUTMAX(I) = -1.0E50
   20 OUTMIN(I) =  1.0E50
      EJM = EJW/G
      STROKE = 0.0
      STRIPT = 0.0
      STRFL = 0.0
      CTH = COS (THETA*DGR)
C
      ITEST = TEST
      IF(TEST.NE.0.0)  ZLF = GDT(ITEST,1)
      WRITE(6,16)  TEST,ITEST,ZLF
   16 FORMAT(1H0,10X,"TEST = ",F10.4,5X,"ITEST = ",I4,5X,"ZLF = ",
     .F10.5)
      IF(ITEST.EQ.0.0)  GO TO 18
      WRITE(6,17) (GDT(ITEST,J),J=1,220)
   17 FORMAT(1H0,10X,"***** G DATA *****",/,22(10F6.1/))
C
   18 CLF = ZLF*CTH
      CASE = NCASE
      PIE = 3.14159
      TLO = VO/PA
      FRF = 0.0
      PDC = SQRT ((4.0/PIE)*PA)
      PC = PIE*PDC
      THA = PC*TLO + 2.0*PA
      GEEZ = 0.0
      EK = 0.0
      EP = 0.0
      AFACT = 4.0/RHOP/PIE
      WRK = 0.0
      WRKDOT = 0.0
      HP = 0.0
      TEMP = CTEMP
      VELC = 0.0
      BRP = 0.0
      BW = 0.0
      FE = 0.0
      HE = 0.0
      ISNUFF = 0
      IFIRST = 0
      NPTW = 0
      TDWDWB = 0.000001
      RFE = 0.0
      PDISTZ = 0.0
      TLF = CLF
      RTEMP = TFLAME - TIG
      DTEMP = TIG - CTEMP
      BBB = B
C
      WRITE (6,13) NCASE,
     .             DT,CO,A1,A2,A3,C,PA,EJW,STROFF,VO,B,PXP,RM,K1,K3,
     .             RHOP,RHO,OMEGA,THETA,ZLF,TFLAME,CV,PLOCK,CTMP,CGD,
     .             RLRD,K2,DPLMT,TIGN,
     .             NPRT,MODE,NOUT,IFPLT,MODEL,ICOND
   13 FORMAT (1H1,"INPUT DATA,     CASE    ",I4,//,
     .            " DT,CO,A1,A2,A3,C"/" PA,EJW,STRPOFF,VO,B,PXP"/" RM,K1,
     ."           "K3,RHOP,RHO,OMEGA"/" THETA,ZLF,TFLAME,CV,PLOCK,CTMP"/
     .            " CGD,RLRD,K2,DPLMT,TIGN"/,
```

```
     .           " NPRT,MODE,NOUT,IFPLT,MODEL,ICOND"//,4(6F14.6/),
     .           5F14.6,/618///)
C
      IF (IFPLT.NE.0) WRITE (6,12) NPT,OUT,NCASE
      RK1(NPT) = 0.0
      PL (NPT) = 0.0
      CT1(NPT) = 0.0
      NPT = NPT + 1
C
      IF (IFPRT.EQ.0) GO TO 4
C
      WRITE (6,14)
   14 FORMAT (1H0," OUTPUT"//,8X,"TIME",66X,"CASE"/9X,"GZ"12X,"VZ",10X,
     ."STROKE"10X,"HT",11X,"VOL",12X,"DRI"/8X,"PBR",12X,"WB",12X,"BA",
     .13X,"W",11X,"TEMP"10X,"PRESS"/9X,"EK",12X,"EP",12X,"EF",12X,"EL",
     .11X,"FORCE",9X,"TAREA"/,8X,"FRF",12X,"RK",10X,"RPLRT",10X,"TLF",
     .11X,"RFE",12X,"BB"/,7X,"WDOT",11X,"WRK",12X,"HP",//)
C
      WRITE (6,12) (OUT(I),I=1,NOUT)
C
    4 CALL INTGRT (TIME,DT,SUM,PSUM,RATE,SAVE,NV,INT)
C
      CALL CAD (TIME,CADF,PRESS,PBR,WB,W,STRFL,STROKE,TEMP,TFLAME,CV,
     .          B,PXP,C,CO,A1,A2,A3,RM,VO,PA,K1,K3,PLOCK,STROFF,EJM,
     .          VELZ,HT,CLF,VOL,THA,ELDOT,WKDOT,WK,EL,MODE,INT,STRIPT,
     .          EFDOT,EF,CTEMP,IDIAG,DPLMT,RK,ISNUFF,MODEL,BB,DT,ICOND,
     .          EPDOT,EP,EKDOT,EK,ACCZ)
C
C     WRITE(6,53)
C  53 FORMAT("OUT OF CAD INTO THE MAIN PROGRAM")
      PBACC = K4*((TIG-CTEMP)*(FDOT*VOL+VOLDOT*PRESS-RM*WDOT*TEMP))/
     .          (RHOP*TEMP*TEMP*RM*W)*(-1.0)
C
C  COMPUTE DISTANCE TRAVELLED THROUGH THE G FIELD AND CATAPULT STROKE...
C
      HT = DISTZ*CTH
      STROKE = DISTZ*12.0
C
C  COMPUTE FRICTION FORCE IN RAILS.........
C
C
      ITEST = TEST
      ITIME = TIME * 1000.
      IF(ITIME.EQ.0)   ITIME = 1
      IF(TEST.NE.0.0)     ZLF = GDT(ITEST,ITIME)
C
      CLF = ZLF*CTH
C     TLF = CLF + ACCZ/G
C     RMOM = EJW*TLF*CGD
C     FRLR = RMOM/RLRD
C     FRF = K2*FRLR*2.0
      FRF = K2*EJW
C
C  SUM THE EXTERNAL FORCES ON THE EJECTED MASS.........
C
      FPF = PA*PRESS*K1
C      ACCZ = (CADF-FRF-FPF )/EJM - CLF*G
      ACCZ = CLF * G
C
C  COMPUTE THERMAL AREA......
C
      THA = PC*(TLO + STROKE) + 2.0*PA
C
C  DON ' 'ST THE EJECTED MASS FALL...........
```

```
C
C     IF (ZLF*G*CTH.GT.CADF/EJM.AND.DISTZ .LE.0.0) GO TO 8
      IF(ACCZ.LT.0.0)   ACCZ = 0.0
C
C  SPINE DEFLECTION ACCELERATION........
C
      ACCB = ACCZ - RO2MGA*VELB - OMGASQ*DISTB
      GEEB = ACCB/G
C
      GO TO 9
C
    8 CONTINUE
      VELZ = 0.0
      DISTZ = 0.0
      ACCZ = 0.0
C
C  CALCULATE NEW RATES FOR INTEGRATION......
C
    9 VELBB = VELB
      VELZZ = VELZ
      IF (IFIRST.EQ.1.OR.ISNUFF.EQ.0) GO TO 400
      WRITE (6,401)
  401 FORMAT (85X," SNUFFED OUT ?????")
      IFIRST = 1
  400 CONTINUE
C
      GO TO (4,4,4,10), INT
C
   10 DRI = OMGASQ*DISTB/G
      GEEZ = ACCZ/G
      VELC = VELZ
      BRP = PBR
      BW = WB
      FE = EF
      HE = EL
      HP = WKDOT/550.
      WRKDOT = WKDOT
      WRK = WK
C
C  COMPUTE FRICTIONAL ENERGY LOST IN RAIL FRICTION.........
C
      RFE = RFE + FRF*(DISTZ - PDISTZ)
      PDISTZ = DISTZ
      ORK = K41
      WDOT = (W-PW)/DT
      IF (MODE.NE.0.0) GO TO 607
      PW = W
      IF (WDOT.LT.0.0) WRITE (6,605)
  605 FORMAT (1H ," WDOT.LT.0.0")
      IF (PBR.GT.0.0) BA = WDOT/PBR/RHOP
      IF (BA.LT.0.0) BA = 0.0
C     IF (BA.GT.0.0) WBDT = WDOT/BA/RHOP
      VOLDOT = PA*VELZ*12.0
      IF (VOLDOT.EQ.0.0) VOLDOT = 0.00001
      FILDOT = 0.0
      IF (PRESS.GT.0.0) FILDOT = RM*TEMP/PRESS*BA*RHOP*PBR
      REPLAT = FILDOT/VOLDOT
      RPLRT = REPLAT
      PDOT = (PRESS - PP)/DT
      PP = PRESS
      IF (TIME.LT.0.1.OR.ICOND.NE.2) GO TO 607
      IF (PBR.GT.0.0) TDWDWB = TDWDWB + WDOT/PBR
      NPTW = NPTW + 1
  607 CONTINUE
```

```
C
C   COMPUTE K41..............
C
       K41 = PBR*RHOP*CV*DTEMP/RTEMP
C
       IPRT = IPRT + 1
       IF (IPRT.EQ.NPRT) GO TO 11
       GO TO 4
  11   IF (IFPRT.EQ.0) GO TO 44
       IF (STROKE.GT.STROFF)
      .WRITE (6,1000)
 1000  FORMAT (1H0,6X,6("STRIPOFF       "))
       WRITE (6,12) (OUT(I),I=1,NOUT)
 12    FORMAT (1H0/,F14.6,56X,F14.6/(6F14.6))
  44   CONTINUE
       DO 21 I=1,NOUT
       OUTMAX(I) = AMAX1 (OUT(I),OUTMAX(I))
  21   OUTMIN(I) = AMIN1 (OUT(I),OUTMIN(I))
C      IF (IFPLT.NE.0) WRITE (6,12) NPT,OUT,NCASE
       IPRT = 0
       CTCC(NPT) = TIME
       PL(NPT) = WB
       CT1(NPT) = W
       PSI(NPT) = PRESS
       PR1(NPT) = PBR
       RK1(NPT) = BB
       GLF(NPT) = ZLF
       GACCZ(NPT)=GEEZ
       DISP(NPT)=STROKE
C
       IF (STRFL.EQ.1.0) GO TO 7
       NPT = NPT + 1
       GO TO 4
C
   7   CONTINUE
C      IF (IFPLT.NE.0) WRITE (11) NOUT,NCASE,NPT,OUTMAX,OUTMIN
       IF (MODE.EQ.0) GO TO 602
       ADWDWB = TDWDWB/(FLOAT(NPTW)+0.000001)
       IF (ICOND.NE.2) GO TO 701
       PL(NPT+1) = (C-W)/ADWDWB + WB
       CT1(NPT+1) = C
 701   CONTINUE
       RK1(NPT+1) = BB
       PSI(NPT+1) = PRESS
       PR1(NPT+1) = PBR
       NPTS = NPT + 1
       IF (MODE.NE.0.AND.ICOND.EQ.2) GO TO 707
C
       GO TO 700
C
 707   DO 909 I=1,NPTS
       IF (CT1(I).LE.0.0) CT1(I) = 0.0
       WBG(I) = PL(I)
 909   WG(I) = CT1(I)
C
 700   CONTINUE
C       IF(NCASE.EQ.0)   GO TO 600
C
C***   WRITE PRESSURE,ACCELERATION,AND DISPLACEMENT DATA TO DISK FILE
C
       WRITE(7,150)  (PSI(I),  I=1,NPTS)
       WRITE(8,150)  (GACCZ(I),  I=1,NPTS)
       WRITE(9,150)  (DISP(I),  I=1,NPTS)
       WRITE(10,150)  (PL(I),  I=1,NPTS)
```

```
      WRITE(11,150)  (CT1(I)*32.174,  I=1,NPTS)
  150 FORMAT(8F10.4)
C
  600 WRITE (6,601) (CTCC(I),CT1(I),PL(I),RK1(I),PSI(I),PR1(I),GLF(I),
     .                  I=1,NPTS)
  601 FORMAT(1H0/////" WEB BURNED VS PROPELLANT CONSUMMED...."//7X"TIME"
     .            7X,"PROPELLANT",8X,"WEB",13X,"B",12X,"PRESS",9X,"PBR",
     .9X, "GFIELD",//,(7F14.7))
C
C
  602 CONTINUE
      B = BBB
      GO TO 1
    6 WRITE (6,15)
   15 FORMAT (2(1H0,/),60X,"END OF JOB")
      STOP "END OF JOB"
      END
      SUBROUTINE CAD (TIME,CADF,PRESS,PBR,WB,W,STRFL,STROKE,TEMP,
     .                TFLAME,CV,B,PXP,C,C0,A1,A2,A3,RM,VO,PA,K1,K3,
     .                PLOCK,STROFF,EJM,STRKDT,HT,CLF,VOL,THA,ELDOT,
     .                WKDOT,WK,EL,MODE,INT,STRIPT,EFDOT,EF,CTEMP,IDIAG,
     .                DPLMT,RK,ISNUFF,MODEL,BB,DT,ICOND,
     .                 EPDOT,EP,EKDOT,EK,ACCZ)
C
C  SUBROUTINE FOR COMPUTING PERFORMANCE OF A CLOSED TELESCOPING TUBE,
C  ACTING AGAINST A LOAD IN ANY G ENVIRONMENT AND USING A BURNING
C  PROPELLANT AS A SOURCE OF ENERGY.........
C .
      COMMON /CATDAT/ PL(250), WBG(250), WG(250), CTCC(250), CT1(250),
     .                RK1(250),PR1(250),NPTS,PSI(250)
C
      REAL K1,K3
C
C  HAS CATAPULT REACHED STRIPOFF........
C
      IF (STROKE - STROFF) 1,1,10
C
C  COMPUTE PROPELLANT CONSUMMED.........
C
    1 IF (MODE.NE.0)
     .W = W + 0.000001
C
      IF (MODE.EQ.0)
     .W = FINTRP (WB,WG,WBG,NPTS)
C
C  HAS ALL THE PROPELLANT BURNED........
C
      IF (W -C) 3,3,2
C
C  AAAAALLLLL BURRRRRRRRNNNNNNNEDDD........
C
    2 W  = C
C
C  COMPUTE INTERNAL VOLUME.....
C
    3 VOL = VO + PA*STROKE
C
C  DONT LET VOLUME DECREASE BELOW INITIAL VALUE.......
C
      IF (VOL) 4,4,5
C
    4 VOL = VO
C
C
```

```
C  COMPUTE THE ENERGY TERMS......
C
       IF (INT.EQ.1) PW = W
       IC = 0
  5    CONTINUE
C
C  WORK PORTION..........(WK).....COMING FROM INTEGRATOR......
C
C  FRICTIONAL ENERGY PORTION....EF.....  COMING FROM INTEGRATOR ROUTINE..
C
C  HEAT ENERGY LOST PORTION......EL....COMING FROM INTEGRATOR ROUTINE...
C
C  POTENTIAL ENERGY PORTION......EP....COMING FROM INTEGRATOR ROUTINE...
C
C  KINETIC ENERGY PORTION........EK....COMING FROM INTEGRATOR ROUTINE...
C
C  COMPUTE SPACE AVERAGE GAS TEMP
C
       TEMP = TFLAME - (WK +  EL)/(W*CV)
C
C  COMPUTE CHAMBER PRESSURE USING EQUATION OF STATE.......
C
       PRESS = RM*TEMP*W/VOL
C
C IF WE ARE TRYING TO FIT TEST DATA, CALL FITTER..........
C
C      WRITE(6,13)   INT, PRESS
C 13   FORMAT(10X,"INT=",I3,3X,"PRESSURE=",F12.5)
       IF(INT.NE.4) GO TO 50
       IF (MODE.EQ.0) GO TO 50
       IF (ICOND.EQ.2) GO TO 60
C
       CALL FITTER (TIME,PRESS,W,IC,ICOND,DPLMT,RK,MODEL,&10,&5,&40)

C
  40   IF (INT.NE.4) GO TO 50
C
       W=W-CO
       WB = FINTRP (W,WBG,WG,NPTS)
       BB = ((WB-PWB)/DT)/ABS(PRESS)**PXP
       B = BB
       PWB = WB
       GO TO 50
C
  60   CONTINUE
C      WRITE(6,14)
C14    FORMAT(3X,"*****COING INTO FITTER*****")
       CALL FITTER (TIME,PRESS,W,IC,ICOND,DPLMT,RK,MODEL,&10,&5,&50)

  50   CONTINUE
C      WRITE(6,15)
C 15   FORMAT("PRESSURE FIT HAS BEEN MADE")
C
C  COMPUTE INTERNAL FRICTIONAL ENERGY RATE.......(POWER)............
C
       EFDOT = ABS(K1*PRESS*STRKDT)
C
C  COMPUTE HEAT LOSS RATE.......
C
       ELDOT = ABS (K3*(TEMP - CTEMP)*THA)
C
C  COMPUTE WORK RATE.......
C
       WKDOT = ABS (CADF * STRKDT)
```

```
C
C  COMPUTE POTENTIAL ENERGY RATE........
C
      EPDOT = EJM*STRKDT*CLF*32.2
C
C  COMPUTE POTENTIAL ENERGY RATE........
C
      EKDOT = EJM*0.5*ACCZ**2.0
C
      PBR = 0.0
      IF (W -C) 6,7,7
C
    6 PBR = B*ABS(PRESS)**PXP
      IF (INT.EQ.4  .AND. PW.EQ.W) PBR = 0.0
      IF (PBR.GE.0.0) GO TO 20
      PBR = 0.0
      ISNUFF = 1
   20 CONTINUE
C
C  HAS PRESSURE UNLOCKED PISTON YET.......
C
    7 IF (PRESS-PLOCK) 8,9,9
C
C  STILL LOCKED.....CATAPULT FORCE IS ZERO.......
C
    8 CADF = 0.0
      GO TO 11
C .
C  UNLOCKED....HIT 'EM UP AND MOVE 'EM OUT........
C
    9 CADF = PA*PRESS
      STRPL = 0.0
      GO TO 11
C
C  STRIPOFF HAS OCCURRED......MARK THE EVENT.......
C
   10 STRFL = 1.0
      STRIPT = TIME
      PRESS = 0.0
      PBR = 0.0
      CADF = 0.0
   11 IF (IDIAG.NE.0)
     .WRITE (6,12)     TIME,CADF,PRESS,PBR,WB,W ,STRFL,STROKE,TEMP,
     .                 TFLAME,CV,B,PXP,C,A0,A1,A2,A3,RM,V0,PA,K1,K3,
     .                 PLOCK,STROFF,EJM,STRKDT,HT,CLF,VOL,THA ,
     .                 EK,EP,EL ,MODE,INT,STRIPT,EFDOT,EF,CTEMP
   12 FORMAT (1H0,(5F14.7))
      RETURN
      END
      SUBROUTINE FITTER (TIME,PRESS,W,IC,ICOND,DPLMT,RK,MODEL,*,*,*)

C
      COMMON /TESTDT/ PP(30,3,3),T(30,3,3),DAT(25,3)
C
      IF (IC.EQ.0)
     .P = FINTRP (TIME,PP(1,ICOND,MODEL),T(1,ICOND,MODEL),30)
      IF (TIME.GT.T(3,ICOND,MODEL).AND.P.EQ.0.0) GO TO 10
C
C     STATEMENT 10: STRIPOFF HAS OCCURRED
C
      DP = P - PRESS
      IF (P.GT.0.0) PRATIO = DP/P
      IF (ABS(PRATIO).GT.1.0.AND.PRESS.GT.0) PRATIO = DP/PRESS
      IF (P.LE.0.0.AND.PRESS.LT.0.0) PRATIO = 0.0
```

```
C
C         WRITE(6,5) DP,DPLMT,P,PRESS
C 5       FORMAT(5X,"DP=",F12.5,3X,"DPLMT=",F12.5,3X,"P=",F12.5,3X,
C        ."PRESS=",F12.5)
          IF (DP) 30,50,30
   30     IF (ABS (DP).LE.DPLMT) GO TO 50
          W = W +  RK*PRATIO*W
C         WRITE(6,6)  W
C 6       FORMAT(5X,"W=",F12.5)
          IF(TIME.GE. 0.155 .AND. TIME.LE. 0.157)
         .WRITE (6,100) TIME,PRESS,P,DP,PRATIO,W,RK,IC
          IF (IC.GT.100)
         .WRITE (6,100) TIME,PRESS,P,DP,PRATIO,W,RK,IC
  100     FORMAT (7F14.7,I10)
          IF (P.EQ.0.0) GO TO 50
          IC = IC + 1
          IF (IC.GT.300) STOP "IC STOP"
          RETURN 2
   50     IC = 0
          RETURN  3
   10     RETURN  1
          END
          SUBROUTINE INTGRT (TIME,DELTIM,STATE,PSTATE,RATE,SAVE,NV,INT)
          DIMENSION RATE(NV),STATE(NV),PSTATE(NV),SAVE(NV)
          DATA HALF/.5/
          IF(INT.EQ.4) INT = 0
          INT=INT+1
          IF(INT.LT.1.OR.INT.GT.4) GO TO 80
          DO 50 I=1,NV
          DELTA=RATE(I)*DELTIM

          GO TO(10,20,30,40),INT
   10     SAVE(I) = DELTA
          DELTA=DELTA*HALF
          PSTATE(I) = STATE(I)
          GO TO 50
   20     SAVE(I) = (DELTA/HALF) + SAVE(I)
          DELTA=DELTA*HALF
          GO TO 50
   30     SAVE(I) = (DELTA/HALF) + SAVE(I)
          GO TO 50
   40     DELTA = (SAVE(I) + DELTA)/6.
   50     STATE(I) = PSTATE(I) + DELTA
          GO TO(60,70,60,70),INT
    60 TIME=TIME+(DELTIM*HALF)
    70 CONTINUE
          RETURN
    80 WRITE (6,90)
    90 FORMAT (1H0,128HILLEGAL VALUE FOR INTEGRATION COUNTER, IT MUST BE
         .INITIALIZED TO A VALUE OF 0 AT THE BEGINNING OF EACH NEW INTEGRATI
         .ON CASE.....)
          STOP
          END
          FUNCTION FINTRP (ARG,ORD,ABSC,NPTS)
          DIMENSION ABSC(NPTS),ORD(NPTS)
          CALL RATIO (NPTS,ARG,ABSC,RATX,I)
          FINTRP = ORD(I) - RATX * (ORD(I) - ORD(I-1))
C         WRITE(6,10)    FINTRP
C 10      FORMAT(1H0,"FINTRP =",F12.5)
          RETURN
          END
          SUBROUTINE RATIO (NV,GV,TV,RAT,NC)
          DIMENSION TV(1)
C
```

```
      IF (NV.EQ.1) GO TO 120
      IF (GV - TV(1)) 120,120,150
  120 NC = 1
  130 RAT = 0.
      GO TO 220
  150 DO 170 NCNT=2,NV
      NC = NCNT
      IF (GV - TV(NC)) 200,130,170
  170 CONTINUE
  190 GO TO 130
  200 RAT = (TV(NC) - GV)/(TV(NC) - TV(NC-1))
C     WRITE (6,5)RAT,TV(NC),GV,TV(NC-1),NC
C   5 FORMAT(1HO,"RAT=",F12.5,3X,"TV(NC)=",F12.5,3X,"GV=",3X,F12.5,
C    ."TV(NC-1)=",3X,F12.5,"NC=",I5)
  220 RETURN
      END
      BLOCK DATA
C
      COMMON /TESTDT/ P(30,3,3),T(30,3,3),DAT(25,3)
C
C  DAT WORD DEF'S....  CO,A1,A2,A3,C,B,PXP,RM,RHOP,CV,TFLAME,PA,STRIPOFF,
C                      VO,K1,K2,K3,PLOCK,EJW,CGD,RLRD
C
C
C  PRESSURE VS TIME CURVES FOR SEVERAL EJECTION CATAPULT FIRINGS AT COLD
C  ROOM AND HOT TEMPERATURES .....(-65 F, 70 F, 165 F)
C
C  CKU5/A.......
C
      DATA (((P(I,J,K),I=1,20),J=1,3),K=1,1) /
     .0.,450.,900.,1750.,2150.,2375.,3150.,3750.,4150.,4370.,4750.,4700.
     .,4650.,4100.,0.0,0.0,0.0,0.0,0.0,0.0,0.,150.,2370.,3500.,5150.,
     .5450.,5450.,5250.,4000.,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,
     .0.0,0.,225.,2250.,2800.,3750.,6000.,7500.,6850.,5990.,0.0,0.0,0.0,
     .0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0/
C
      DATA (((T(I,J,K),I=1,20),J=1,3),K=1,1) /
     .0.0,.01,.02,.03,.035,.04,.06,.08,.1,.12,.14,.16,.168,.179,.179,
     ..180,.181,.182,.183,.184,0.0,.002,.03,.06,.11,.13,.15,.16,.171,
     ..171,.172,.173,.174,.175,.176,.177,.178,.179,.180,.181,0.0,.003,
     ..03,.04,.06,.10,.132,.145,.156,.156,.157,.158,.159,.160,.161,.162,
     ..163,.164,.165,.166/
C
      DATA ((DAT(I,J),I=1,23),J=1,1) /
     .0.0002    ,2.1930318,14.8387570,-47.0218638,0.00385,0.0335,0.41,
     .42084.,0.0019581,17567.,3480.,0.7854,33.996,19.5,0.05,0.01,0.3,
     .10.,333.96,.935,0.75,500.,0.000001/
C
C  TALLY 2400..........   PRESSURE/TIME DATA FROM TEST 183
C
      DATA (((P(I,J,K),I=1,20),J=1,3),K=2,2)  /
     .             0.0,140.,250.,355.,475.,605.,740.,880.,1015.,1120.,1200.,
     .1240.,1255.,1245.,1220.,1185.,1145.,0.0,0.0,0.0,
     .0.0, 4.3,38.6,128.,618.8,
     .876.3,1323.,1680.,1790.,1893.,1988.8,2187.9,2187.9,2119.3,
     .2085.,2040.,1508.1,1295.2,581.1 ,0.0,
     .0.0,405.,605.,
     .825.,1070.,1310.,1670.,1725.,1725.,1685.,1630.,1565.,1530.,0.0,
     .0.0,0.0,0.0,0.0,0.0,0.0 /
C
      DATA (((T(I,J,K),I=1,20),J=1,3),K=2,2) /
     .             0.0,.008,.02,.03,.04,.05,.06,.07,.08,.09,.10,.11,.12,.13,
     ..14,.15,.15,.161,.165,.17,
     .0.0,.001,.002,.009,.049,.064,.084,.099,.104,.109,.114,.129,.134,
```

```
      ..149,.154,.159,.184,.194,.196,.197,
      .0.0,
      ..01,.02,.03,.04,.05,.06,.07,.08,.09,.10,.11,.12,.13,.135,.136,
      ..14,.15,.16,.17/
C
      DATA ((DAT(I,J),I=1,23),J=2,2) /
      .0.000069 ,3.6672767,-11.5071002,103.9582915,0.0044  ,0.0189,0.46,
      .40526.,0.0019581,16032.,3876.,4.079,32.48,20.28,0.02,0.01,.3,44.82
      .,350.,1.0,0.75,500.,0.000001/
C
      END
      BLOCK DATA
C
      COMMON  /GDATA/ GDT(3,220)
C
C
C     ACCELERATION ENVIRONMENT IN WHICH CATAPULT IS FIRING(CARRIER
C     SLED ACCELERATION).  DATA IS STORED IN 1 MSEC INTERVALS.
C
C     TEST 171......      I = 1
C
      DATA((GDT(I,J), I=1,1), J=1,220)/
      .7.9,  8.0,  8.0,  8.1,  8.1,  8.1,  8.1,  8.1,  8.1,  8.1,
      .8.1,  8.2,  8.1,  8.1   8.1,  8.3,  8.4,  8.5,  8.5,  8.4,
      .8.5,  8.4,  8.3,  8.2,  8.2,  8.1,  8.2,  8.2,  8.3,  8.4,
      .8.4,  8.4,  8.4,  8.3,  8.3,  8.3,  8.3,  8.3,  8.3,  8.3,
      .8.3,  8.2,  8.2,  8.2,  8.2,  8.3,  8.2,  8.3,  8.3,  8.3,
      .8.3,  8.3,  8.3,  8.3,  8.4,  8.4,  8.5,  8.4,  8.5,  8.5,
      .8.4,  8.4,  8.5,  8.5,  8.5,  8.7,  8.6,  8.7,  8.8,  8.8,
      .8.9,  8.9,  8.9,  8.9,  9.0,  9.0,  9.0,  8.9,  8.9,  8.9,
      .8.9,  8.8,  8.8,  8.7,  8.7,  8.7,  8.5,  8.1,  6.9,  4.4,
      .1.4,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0/
C
C     TEST 183......      I = 2
C
      DATA((GDT(I,J), I=2,2), J=1,220)/
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.2,
      .0.3,  0.4,  0.4,  0.3,  0.4,  0.6,  0.8,  0.9,  1.2,  1.8,
      .2.0,  2.5,  2.7,  2.9,  3.1,  3.5,  3.8,  4.2,  4.2,  4.4,
      .4.7,  5.1,  5.2,  5.4,  5.7,  5.9,  6.1,  6.3,  6.5,  7.0,
      .7.2,  7.5,  7.7,  7.9,  8.2,  8.4,  8.6,  8.8,  9.0,  9.4,
      .9.7, 10.0, 10.4, 10.5, 10.9, 11.2, 11.6, 11.8, 11.7, 11.9,
      .12.2, 12.5, 12.8, 13., 13.2, 13.7, 13.8, 13.8, 13.9, 14.1,
      .14.3,14.4, 14.5, 14.6, 14.7, 14.6, 14.4, 14.0, 14.0, 14.0,
      .14.2,14.3, 14.3, 14.5, 14.4, 14.6, 14.6, 14.5, 14.3, 14.3,
      .14.3,14.2, 14.1, 14.0, 14.0, 14.2, 14.0, 13[illegible] 13.9, 13.7,
      .13.7,13.5, 13.2, 13.1, 13.1, 13.2, 12.9, 12[illegible] 12.4, 12.1,
```

```
      .11.9,11.8, 11.5, 11.3, 11.1, 10.9, 10.6, 10.2,  9.7,  9.3,
      .9.1,  9.2,  9.0,  8.7,  8.5,  8.3,  8.2,  7.8,  7.4,  7.1,
      .6.8,  6.6,  6.2,  5.8,  5.9,  7.2,  9.9,  13.0, 15.0, 15.6,
      .15.2,14.3, 13.4, 12.5, 12.0, 10.2,  8.0,  5.7,  4.5,  3.9,
      .4.1,  4.3,  3.8,  3.5,  3.0,  2.2,  0.9, -0.4, -1.7, -2.8,
      .-3.2, 0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0/
C
C     TEST 180......      I = 3
C
      DATA((GDT(I,J), I=3,3), J=1,220)/
      .8.1,  8.2,  8.1,  8.1,  8.1,  8.1,  8.2,  8.3,  8.3,  8.4,
      .8.4,  8.4,  8.4,  8.4,  8.3,  8.4,  8.4,  8.4,  8.4,  8.5,
      .8.5,  8.5,  8.6,  8.6,  8.7,  8.7,  8.8,  8.9,  8.9,  8.9,
      .8.9,  9.0,  9.0,  9.0,  9.0,  9.0,  9.1,  9.0,  9.0,  9.0,
      .9.0,  9.0,  8.9,  8.9,  8.9,  8.9,  9.0,  9.0,  9.1,  9.1,
      .9.2,  9.1,  9.1,  9.2,  9.2,  9.3,  9.3,  9.3,  9.3,  9.3,
      .9.3,  9.2,  9.2,  9.2,  9.3,  9.2,  9.2,  9.1,  9.1,  9.2,
      .9.1,  9.1,  9.1,  9.1,  9.1,  9.1,  9.1,  9.0,  9.0,  9.0,
      .8.9,  8.9,  8.9,  8.8,  8.8,  8.7,  8.8,  8.7,  8.7,  8.7,
      .8.6,  8.6,  8.6,  8.6,  8.6,  8.6,  8.5,  8.5,  8.5,  8.5,
      .8.5,  8.4,  8.4,  8.4,  8.4,  8.4,  8.3,  8.3,  8.3,  8.2,
      .8.3,  8.3,  8.4,  8.3,  8.3,  8.3,  8.3,  8.4,  8.4,  8.4,
      .8.4,  8.4,  8.5,  8.5,  8.5,  8.4,  8.5,  8.5,  8.5,  8.5,
      .8.5,  8.5,  8.5,  8.5,  8.4,  8.3,  8.3,  8.3,  8.3,  8.4,
      .8.3,  8.5,  8.4,  8.4,  8.5,  8.5,  8.6,  8.6,  8.7,  8.7,
      .8.8,  8.8,  8.9,  8.9,  8.9,  9.1,  9.1,  9.1,  9.2,  9.2,
      .9.3,  9.4,  9.4,  9.5,  9.5,  9.6,  9.6,  9.6,  9.7,  9.7,
      .9.8,  9.8,  9.9,  9.9, 10.0, 10.0, 10.1, 10.1, 10.1, 10.1,
      .10.2, 10.1, 10.2, 10.2, 10.2, 9.9,  8.9,  6.4,  2.8,  0.0,
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
      .0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0/
C
      END
$
```

```
&NEWSET
              C = 0.0044,
             CO = 0.000069,
           TEST = 2.        ,
              B = 0.0189    ,
            PXP = 0.46      ,
             RM = 40526.0   ,
           RHOP = 0.0019581,
             CV = 16062.0   ,
         TFLAME = 3876.0    ,
             PA = 4.076     ,
         STROFF = 32.48     ,
             VO = 20.28     ,
             K1 = 0.008     ,
             K2 = .356      ,
             K3 = 0.3       ,
          PLOCK = 44.82     ,
            EJW = 395.00    ,
            CGD = 0.935     ,
           RLRD = 0.75      ,
            RHO = 0.224     ,
            ZLF = 0.0       ,
          THETA = 0.0       ,
          DPLMT = 1.0       ,
          IFPRT = 1         ,
             DT = 0.001     ,
          OMEGA = 52.9      ,
           NPRT = 2         ,
          IFPLT = 0         ,
          MODEL = 2         ,
           MODE = 2         ,
           TIGN = 500.      ,
           CTMP = 70.       ,
             K4 = 0.25      ,
             RK = 0.5       ,
          ICOND = 2         ,
          IDIAG = 0         ,
           NOUT = 29        ,
         ISTOPQ = 0         ,
              &END
  &NEWSET
           MODE = 0         ,
              &END
  &NEWSET
         ISTOPQ = 1         ,
              &END
```